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Mineral Development Division
Department of Mines and Energy
Government of Newfoundland and Labrador

CURRENT RESEARCH

Report 83-1

Compiled and Edited by
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St. John's, Newfoundland
1983

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PREFACE

This publication is the tenth in the Mineral Development Division's annual Report of Activities series.

In 1982, the Division continued, at a slightly reduced level, the program of geoscientific studies begun under the 1976-1982 Canada-Newfoundland Mineral Development Subsidiary Agreement. Geological mapping concentrated on the Grenville Province in Labrador and on the south-central part of the island of Newfoundland, but projects were also started in the Torngat Mountains in Labrador, and were continued in the Cambro-Ordovician carbonates on the west coast of the island. Geochemical field studies concentrated on detailed follow-up studies of anomalies over granitic terranes on the island; the Geological Survey of Canada conducted a major lake sediment geochemical survey in southwestern Labrador.

The Mineral Deposits Section continued its metallogenic study of clastic-hosted mineral deposits in Newfoundland, and started a new study of volcanogenic sulfide deposits in western Notre Dame Bay. The section continued its mineral commodity assessment work, concentrating this year on barite, as well as its mineral inventory program.

The Environmental Geology Section moved from reconnaissance level assessment of aggregate deposits to more detailed surveys of aggregate resources in critical areas. The program of surficial mapping was continued in the Buchans area. The Publications and Information Section's activities were highlighted by the publication of the first five in the Division's colored geological map series, and by the completion of construction of drill core libraries at Pasadena and Goose Bay.

In 1982, a new, two-year cooperative geoscientific program was started with the Federal Department of Energy, Mines and Resources. Projects carried out under this cooperative program are identified in this report. Some of these projects were funded by the Geological Survey of Canada and led by G.S.C. personnel. We thank the Geological Survey of Canada for permission to include reports on these projects in this publication.

B. Greene, Director of Mineral Development

Any reader who would like to write a rebuttal to, or discussion of, any report contained in this volume is invited to submit it to the editor by November 1, 1983, to be considered for inclusion in Report 84-1.

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NEWFOUNDLAND MAPPING SECTION

1. Ian Knight carried out 1:50,000 scale mapping in the Port Saunders and Castors River map areas (12I/11, 14 and 15), western Newfoundland.
2. Doug Boyce did detailed systematic, biostratigraphic sampling for trilobites and conodonts in the Port Saunders and Castors River areas (12I/11, 14 and 15), western Newfoundland.
3. Steve Colman-Sadd mapped parts of Cold Spring Pond (12A/1) and West Gander River (2D/11) areas at 1:50,000 scale.
4. Frank Blackwood mapped the Facheux Bay (11P/9) area at 1:50,000 scale.
5. Jim Hibbard carried out reconnaissance mapping in the Corner Brook map area (12A/13). A final memoir on the Baie Verte Peninsula is in progress.
6. Lawson Dickson and Steve Tomlin carried out detailed mapping and rock geochemical sampling in the D'Espoir Lake area (11P/16) at 1:50,000 scale.
7. Sean O'Brien completed 1:50,000 scale mapping of the Peter Snout (11P/13) map area.

LABRADOR MAPPING SECTION

8. Bruce Ryan began a 1:50,000 scale mapping program across the Nain - Churchill Province boundary in the Torngat Mountains of Northern Labrador (14L/6, 7).
9. Andy Thomas extended his previous regional mapping at 1:100,000 scale south into the Winokapau Lake area (13E SW) of the western Grenville Province.
10. Richard Wardle mapped a structural cross-section at 1:100,000 scale of the Nain - Churchill Province boundary in the Nachvak Fiord of northern Labrador (14M/3, 4) and also carried out some follow-up sampling in the Labrador Trough.
11. Ges Nunn started mapping at 1:100,000 scale in a new project area (23H/SE) in the western Grenville Province.
12. Philippe Erdmer, on contract to the Federal Department of Energy, Mines and Resources, mapped in the Grenville Province along the north shore of Lake Melville (13F/16, 13G/13, 14).

GEOCHEMISTRY SECTION

13. John McConnell commenced follow-up geochemical studies on base metal and uranium anomalies associated with granitoid rocks north of Fortune Bay, north of Francois, and in the Granite Lake area.

MINERAL DEPOSITS SECTION

14. Paul Dean and Jamie Meyer continued a study of the mineral potential of the clastic sedimentary basins of Newfoundland concentrating on the Avalon Peninsula and the Bay of Islands.
15. Ambrose Howse carried out a detailed assessment of barite occurrences on the Avalon Peninsula and in western Newfoundland.
16. Baxter Kean initiated a two-year regional metallogenic study of the Lush's Bight Group, Notre Dame Bay.
17. Cindy Saunders carried out a detailed study of the Betts Cove copper deposit.

ENERGY, MINES AND RESOURCES - MINERAL DEPOSITS STUDIES

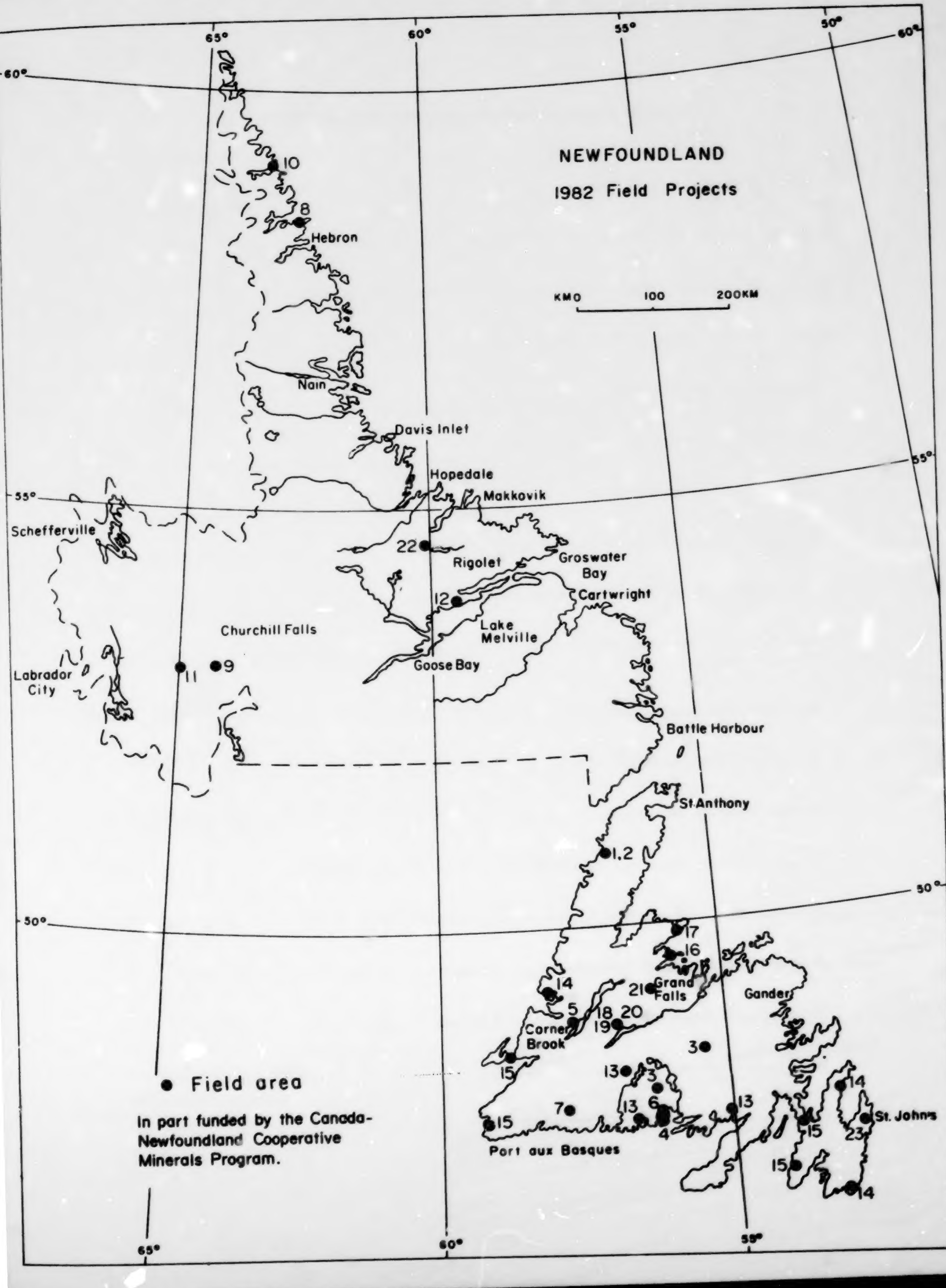
18. Peter Stewart carried out a detailed study of the granite boulders in the Buchans ore breccias.
19. Paul Binney carried out a detailed study of the nature and origin of the Buchans ore breccias.

ENVIRONMENTAL GEOLOGY SECTION

20. Byron Sparkes carried out surficial and glacial mapping of the Buchans map area (12A/15) in the Central Mobile Belt.
21. Doug Vanderveer did preliminary glacial mapping in the Great Gull Lake map area.
22. Rod Klassen of the Department of Energy, Mines and Resources, carried out surficial mapping in the Melody Lake area, Central Mineral Belt, Labrador.
- Detailed aggregate assessment was done by Fred Kirby in selected areas throughout Newfoundland.
23. Martin Batterson began a study of the surficial geology in the St. John's area.

PUBLICATIONS AND INFORMATION SECTION

- Alvin Harris is continuing the program of collection and storage of exploration drill core in Newfoundland and has begun work in Labrador.



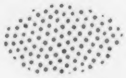
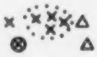
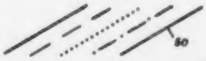
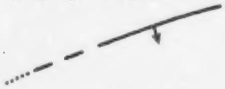
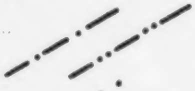
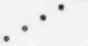
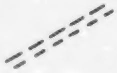
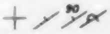
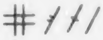
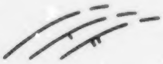
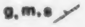
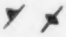
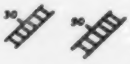
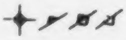
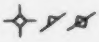
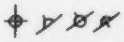
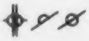
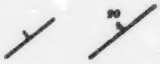
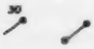
NEWFOUNDLAND

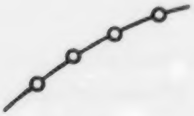
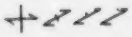
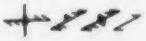
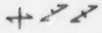
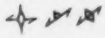
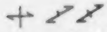
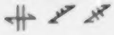
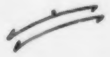
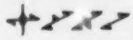
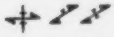
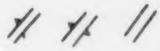
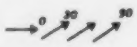
1982 Field Projects

● Field area

In part funded by the Canada-Newfoundland Cooperative Minerals Program.

LIST OF SYMBOLS USED ON GEOLOGICAL MAPS AND FIGURES

Drift covered area	
Rock outcrop, area of outcrop, probable outcrop, float, frost-heaved rock	
Geological boundary (defined, approximate, assumed, gradational, dip indicated)	
Intrusive contact with younger unit indicated	
Unconformity (defined, assumed)	
Limit of geological mapping	
Limit of area surveyed with aircraft	
Bedding, tops known (horizontal, inclined, vertical, overturned)	
Bedding, tops unknown (horizontal, inclined, vertical, dip unknown)	
Bedding, general trend (dip unknown, top unknown; dip and top known; dip known, top unknown)	
Bedding, estimated dip (gentle, moderate, steep)	
Igneous flow banding (inclined, vertical)	
Igneous intrusive sheets (inclined, vertical)	
Primary igneous layering, tops known (horizontal, inclined, vertical, overturned)	
Primary igneous layering, tops unknown (horizontal, inclined, vertical)	
Strike and dip of pillows, tops known (horizontal, inclined, vertical, overturned)	
Strike and dip of pillows, tops unknown (horizontal, inclined, vertical)	
Primary igneous mineral lamination (inclined, vertical)	
Primary igneous mineral lineation (inclined, vertical)	

Flow Contact	
Zone containing xenoliths	△
Zone of intrusive agmatite	▲
Roof pendant (unit number indicated, too small to map separately)	△
Zone containing autoliths	▽
Breccia of various origins	▼
Slaty cleavage (horizontal, inclined, vertical, dip unknown)	
Strain-slip cleavage (horizontal, inclined, vertical, dip unknown)	
Schistosity, cleavage, foliation; used where ages of foliation are indicated on the map (horizontal, inclined, vertical)	
Schistosity of unknown age	
S_1	
S_2	
Schistosity, gneissosity, cleavage, foliation, general trend	
Gneissic foliation (horizontal, inclined, vertical, dip unknown)	
Gneissic banding (horizontal, inclined, vertical)	
Axial plane of minor fold (inclined, vertical, dip unknown)	
Lineation (horizontal, inclined, inclined but plunge unknown, vertical)	
Type of lineation denoted by letter:	
Mineral lineation	M→
S intersections	S→
Microcrenulations	C→
Boudin axes	B→
Deformed clasts	D→
Igneous inclusions	I→
Rodding, mullion structure	R→
Metamorphic aggregates	A→
Deformed pillows	P→

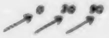
Age of lineation and of minor fold axes

Lineation of unknown age

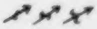
L_1

L_2

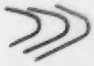
Axes of minor folds (horizontal, inclined, vertical)



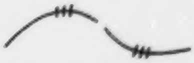
Sense of vergence of minor structures (used with minor fold axes symbol or lineation S intersection symbol; read looking along the arrow)



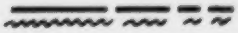
Structural trend (from aerial photographs)



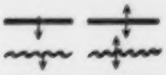
Lineament (from aerial photographs)



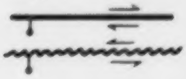
Fault (defined, approximate, assumed)



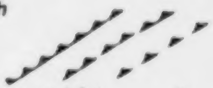
Fault (inclined, vertical)



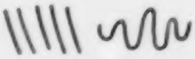
Fault (solid circle indicates downthrown side, arrows indicate relative movement)



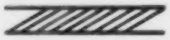
Thrust fault (teeth in direction of dip; defined, approximate, assumed) (teeth indicate upthrust side)



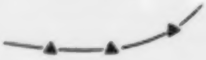
Zone of numerous imbricate thrust faults



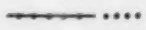
Fault zone, shear zone (width indicated)



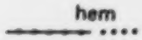
Tectonic slide



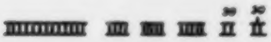
Vein fault (defined, assumed)



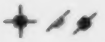
Mineralized bed or seam (hematite)



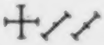
Dike, vein, or stockwork (defined, approximate, assumed; unit number and dip indicated)



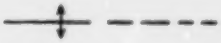
Joint (horizontal, inclined, vertical)

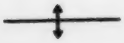
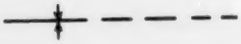
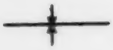
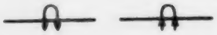
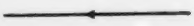
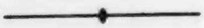
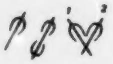
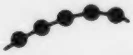
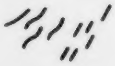
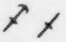
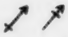
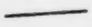
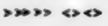
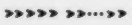
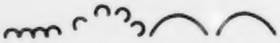
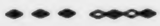
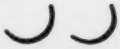
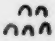
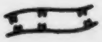


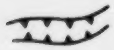
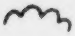
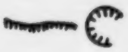
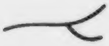
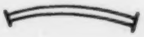
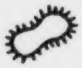
Sheeted dikes (horizontal, inclined, vertical)

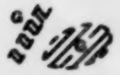


Anticline (defined, approximate, assumed)



Antiform	
Syncline (defined, approximate, assumed)	
Synform	
Anticline and syncline (overturned)	
Anticline or syncline (arrow indicates plunge)	
Antiform or synform	
Glacial striae (direction of ice movement known, unknown). Numbers indicate relative age, 1 being the oldest	
End moraine	
Minor moraines, rib moraines, washboard moraines, "annual" moraines, till ridges transverse to ice flow (irregular, straight)	
Drumlins, drumlinoid ridges (direction of ice movement known, unknown)	
Crag and tail hills and ramps	
Glacial linear feature	
Pingo or palsen	
Esker (direction of flow known, unknown)	
Esker (continuous, discontinuous)	
Raised beaches	
Limit of marine or lacustrine submergence (well marked, assumed)	
Dunes	
Area of sand dunes	
Buried valley	

Abandoned river channel, spillway, ice-marginal channels, rill patterns, etc.	
Landslide scar	
Escarpment and cirques	
Fossil locality	Ⓕ
Locality where age has been determined, in millions of years	Ⓐ 180
Ice divide	— — —
Land system boundary	
Location of measured section	
Gravel pit or quarry (active, abandoned)	× ×̲
Borrow pit (active, abandoned)	×̄ ×̲̄
Rock dump or tailings	
Rock quarry (active, abandoned)	⚒̲
Mine (lead, zinc)	⚒ Pb.Zn
Mine (lead, zine; abandoned)	⚒̲ Pb.Zn
Mineral prospect; mineral occurrence (manganese)	×● × Mn
Placer deposit (gold)	× Au
Show of oil and gas (abandoned)	✸
Show of gas(abandoned)	☼
Gas producer	○
Oil producer	✹
Oil and gas producer	●

Location of drilling	○
Dry (abandoned)	✧
Water source or disposal	◇
Shearing and dip	
Salt spring	ss○
Hot spring	hs○
Mineral isograd	—■—■—■—■—■—
Other alternatives when more than one	⌑ ○ ● △ ▲
Shaft, raise, winze	◪ ■ ⧄
Shaft (abandoned)	◙
Trench	≍
Open cut; axial	∩
Adit or tunnel	≻— ≻=
Adit or tunnel (caved)	≻≁ ≻≠
Borehole	●BH ●BH 3
Diamond drill hole	● DDH
(Surface projection of geology inferred)	—○
Sinkhole	○ SH
Gossan	G 
Trace of coal seam	—— ——

ADDITIONAL SYMBOLS

Geological boundary (geophysically defined)	
Geophysical conductor	
Roche moutonnee	↗
Meltwater channel	
Sinkhole	SH
Open pit, mine or quarry	
Locality where age has been determined, in thousands of years before the present	Ⓕ$^{12.5}$
Till fabric (direction known, unknown, known plus cross fabric)	

SAMPLE LOCALITIES (SURFICIAL)

Glacial till	●
Gravel	●
Sand	○
Silt	■
Clay	+
Organic	✱
Rock	Ⓡ
Pleistocene fossil	Ⓕ

GEOLOGY OF CAMBRO-ORDOVICIAN ROCKS IN PARTS OF THE CASTORS RIVER, ST. JOHN ISLAND AND PORT SAUNDERS MAP SHEETS

by

Ian Knight

INTRODUCTION

1:50,000 scale geologic mapping and detailed stratigraphic compilation of Cambro-Ordovician carbonate rock units within contiguous areas of the Castors River (12I/15), St. John Island (12I/14) and Port Saunders (12I/11) map sheets (Figures 1 and 2) began during the summer of 1982. This heavily wooded region includes substantial areas of forest cutovers, new forest growth and tuckamore spruce. Large open marshes occur on the New Ferolle and Castors Point Peninsulas and in areas east of Port au Choix. The terrain is generally of low elevation and rarely exceeds 75 m. Topographic features include broad ridges separated by forested or marshy, flat, narrow, fault- or bedding-controlled valleys. Narrow, steep-sided ridges occur near the St. John Highlands. In the north and centre of the area, the coast is rocky and irregular, consisting of small bays and promontories. Large east trending bays occur in the south of the area. Access to the map area is provided by the Viking Highway (Route 73) and several gravel and paved branch roads that link to Port au Choix, Bartlett's Harbour and Reef's Harbour. Outcrop is best located on the wooded and locally barren slopes of the ridges, as well as in the bottoms of sink holes that abound in many of the low-lying wooded and marshy valleys of the southern part of area. Drift cover is generally just a few metres thick. Only in the vicinity and east of Port Saunders do several metres of coarse glacial debris (and local sand dune deposits) fill major fault-controlled valleys.

GEOLOGIC SETTING

Most of the map area is underlain by generally gently dipping platformal carbonate rocks that range in age from Middle Cambrian to Middle Ordovician. In the southern half of the area, these rocks are transected by several northeast trending faults. To the north, some of the faults coalesce into the Ten Mile Lake fault. It separates Cambro-Ordovician carbonate rocks in the west from an uplifted eastern terrain of Lower Cambrian clastic and carbonate rocks sitting upon Precambrian basement. The uplifted terrain comprises the Highlands of St. John and Mount St. Margaret.

Stratigraphic subdivision in the area follows that previously used by Knight (1978, 1980).

STRATIGRAPHY

Unit 1

Precambrian basement rocks composed of pink and salmon-red granites form a narrow zone of outcrop at the foot of Mount St. Margaret and the Highlands of St. John. The granular, porphyritic to pegmatitic granites consist of quartz and K-feldspar with variably developed chlorite. The unit lies adjacent to the Ten Mile Lake Fault and is the southern extension of basement rocks previously thought to be confined to the Ten Mile Lake area (Williams, 1967, 1978).

Unit 2

Unit 2 (Labrador Group) is composed, in ascending order, of the Bradore, Forteau and Hawke Bay Formations.

Contribution to Canada-Newfoundland co-operative mineral program 1982-84. Project carried out by Newfoundland Department of Mines and Energy.

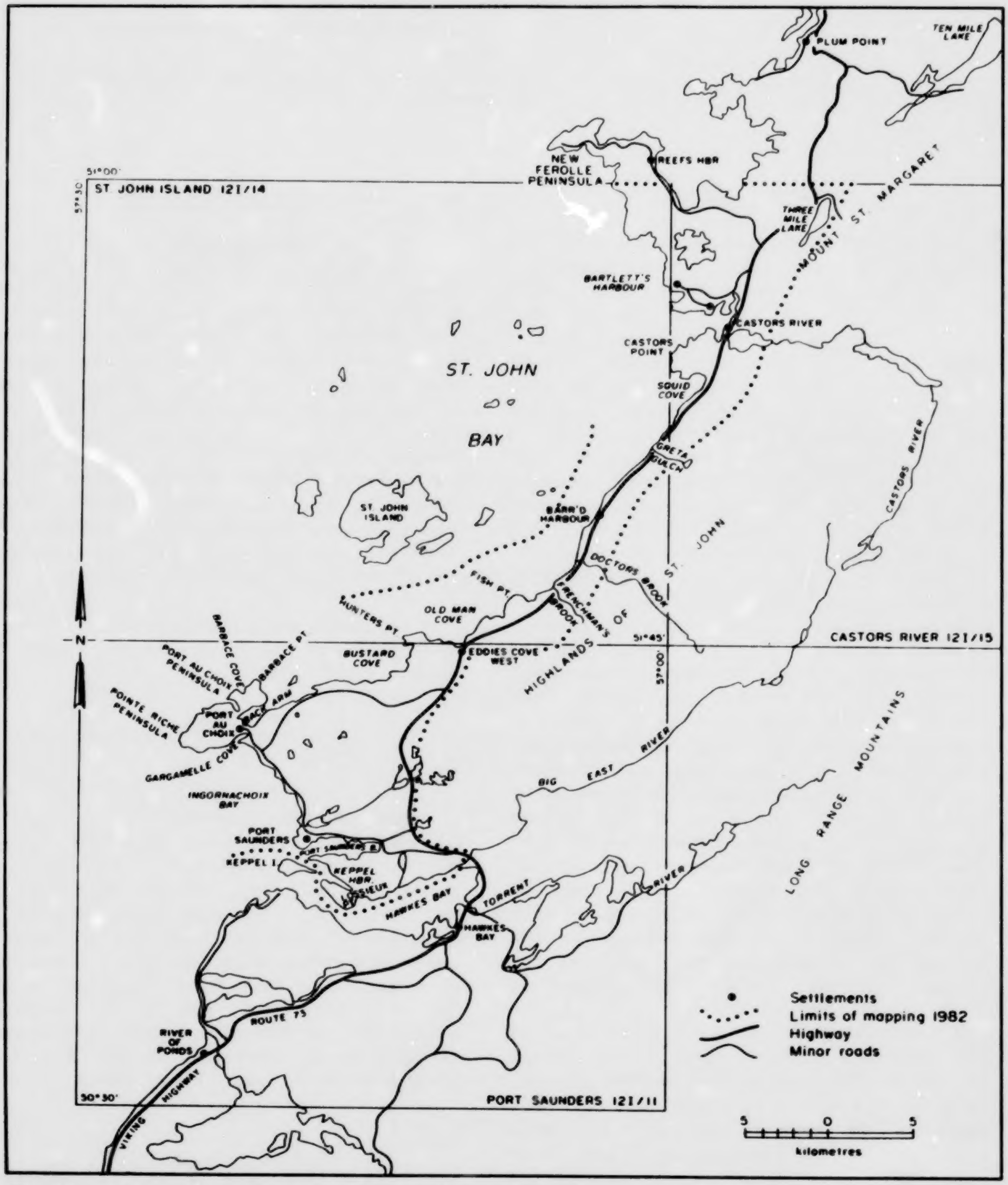


Figure 1: Geographic sketch map of parts of the Castors River, St. John Island and Port Saunders Map Areas.

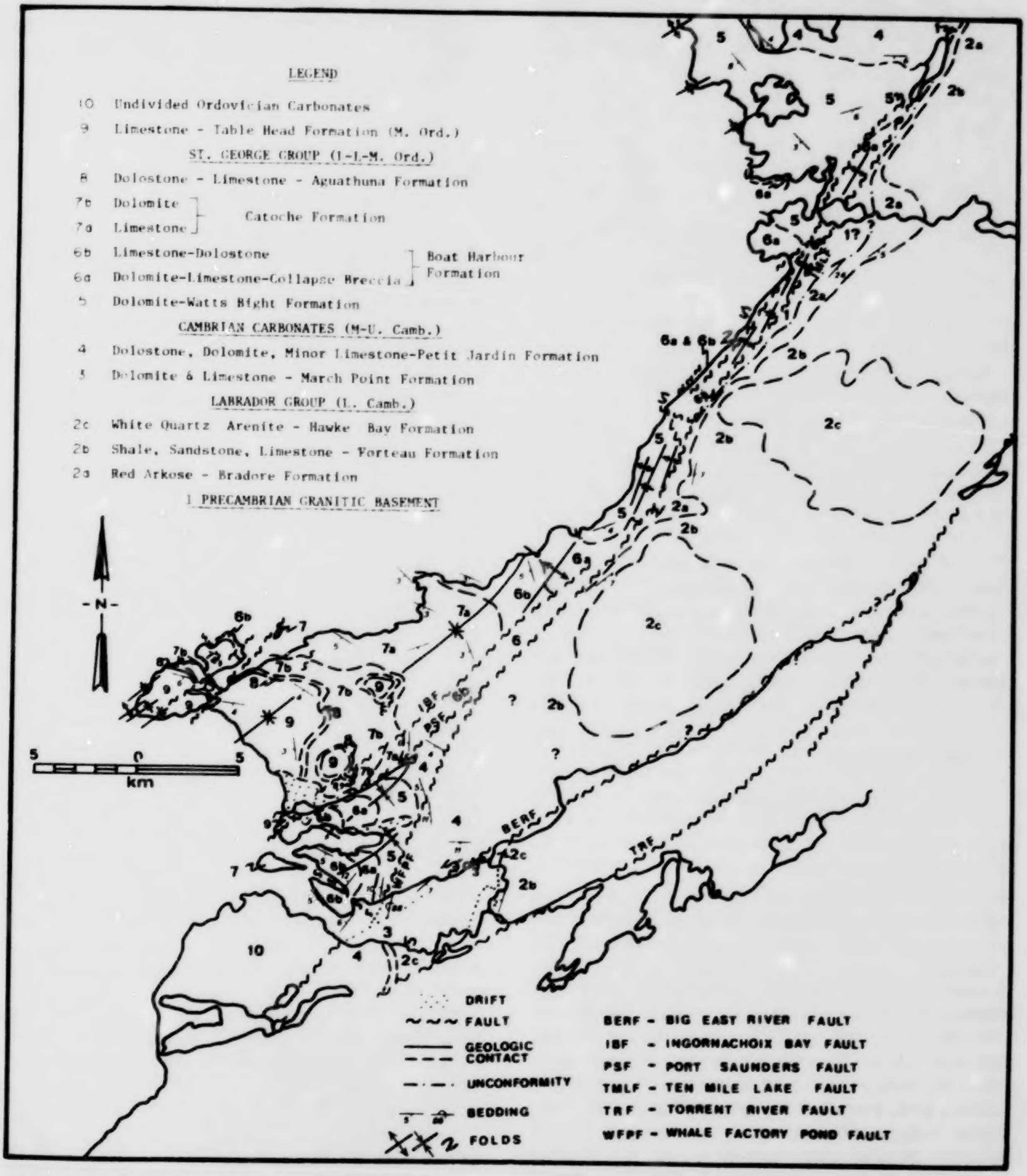

LEGEND
10 Undivided Ordovician Carbonates
9 Limestone - Table Head Formation (M. Ord.)
ST. GEORGE GROUP (1-L-M. Ord.)
8 Dolostone - Limestone - Aguathuna Formation
7b Dolomite
7a Limestone
Catoche Formation
6b Limestone-Dolostone
6a Dolomite-Limestone-Collapse Breccia
Boat Harbour Formation
5 Dolomite-Watts Bight Formation
CAMBRIAN CARBONATES (M-U. Camb.)
4 Dolostone, Dolomite, Minor Limestone-Petit Jardin Formation
3 Dolomite & Limestone - March Point Formation
LABRADOR GROUP (L. Camb.)
2c White Quartz Arenite - Hawke Bay Formation
2b Shale, Sandstone, Limestone - Forteau Formation
2a Red Arkose - Bradore Formation
1 PRECAMBRIAN GRANITIC BASEMENT
N
5 0 5
km
DRIFT
FAULT
GEOLOGIC CONTACT
UNCONFORMITY
BEDDING
FOLDS
BERF - BIG EAST RIVER FAULT
IBF - INGORNACHOIX BAY FAULT
PSF - PORT SAUNDERS FAULT
TMLF - TEN MILE LAKE FAULT
TRF - TORRENT RIVER FAULT
WFPF - WHALE FACTORY POND FAULT
BERF
TRF
IBF
PSF
10
9
8
7
7a
7b
6a
6b
6a & 6b
5
4
3
2a
2b
2c
?

Figure 2: Geologic sketch map of parts of the Castors River, St. John Island and Port Saunders Map Areas. Geology of the Highlands of St. John partly taken from Bostock *et al.*, 1976.

The Bradore Formation (2a) unconformably overlies Unit 1 at the foot of Mount St. Margaret and at the northern end of the Highlands of St. John; the unconformity is truncated by the Ten Mile Lake Fault. The formation consists of red to brown arkosic grits and sandstones, which exhibit planar bedding and crossbedding. Lenses of quartz-pebble conglomerate also occur. A sequence of planar-bedded gray sandstones intruded by a 60 cm thick, green-gray diabase sill outcrops on Doctors Brook.

Rocks of the overlying Forteau Formation (2b) consist of gray and black shales and calcareous mudstones, interbedded with ripple bedded, bioclastic black limestones and thin, rusty weathering gray sandstones. Massive archaeocyathid-bearing limestones occur in outcrops 5 km southwest of Doctors Brook.

White, red and gray quartz arenites form the Hawke Bay Formation (2c). The formation caps the Highlands of St. John and was mapped elsewhere in the map area only as faulted and folded strata on the northeast shore of Hawkes Bay. The quartz arenites are dominantly crossbedded but also exhibit ripple marks and trace fossils.

CAMBRIAN CARBONATE ROCKS

Unit 3

This unit, referred to elsewhere as the Micrite formation (Knight, 1978) and later as the March Point Formation (Knight, 1980), is of late Middle Cambrian age. It occurs only as folded and faulted strata on the northeast shore of Hawkes Bay. The unit, which is at least 35 m thick sits conformably upon unit 2c. It consists of a basal unit of black shales overlain by rusty weathering, well bedded, dark gray to black dolomitic limestones which exhibit flaser and lenticular bedding, bioturbation, scour-based intraformational breccias and some ripple marks. Minor beds of oolitic grainstone also occur. Inarticulate brachiopods have been recovered from both the shales and limestones.

The formation was probably deposited in intertidal to subtidal environments.

Unit 4

Unit 4 (Dolomite formation, Knight, 1978; Petit Jardin Formation, Knight, 1980) consists of apparently unfossiliferous, yellow weathering, pale gray dolostones, green, red and rarely black dolomitic shales and minor blue-gray limestones, of presumed Late Cambrian age. It is exposed in the southeast portion of the map area along and inland from the north shore of Hawkes Bay and on the northern edge of the Castors River map sheet from South Cove to the north end of Three Mile Pond. Elements of four members defined elsewhere on the Northern Peninsula (Knight, 1980) occur in the map area but are not differentiated on the map. The lower contact of the unit is faulted out and continuity of section is disrupted by faults so that thickness cannot be determined.

The dolomites vary from light gray, thin-bedded dolostones to thick-bedded (>50 cm), fine to medium crystalline, pale gray epigenetic dolomites. Original sedimentary structures preserved in the thin-bedded dolostones include planar bedding, ripple marks, planar lamination, ripple cross-lamination, mudcracks, tepee structures and minor bioturbation. Intraformational breccias are also common. Green and red dolomitic shales and shaly dolostones exhibiting mudcracks form 1-2 m units in the lower half of the formation. In the middle of the formation, large, domal stromatolites are associated with crossbedded, intraclastic oolitic lime grainstones and bedded dolostones. The stromatolites, which are composed of both limestone and dolostone exhibit columnar and laminar internal structures. West of Whale Factory Pond on the north shore of Hawkes Bay the upper half of the formation is dominated by massive and thick-bedded, crystalline dolomites locally exhibiting bioturbation, chert and collapse breccias. Blue chalcedonic, quartz-filled vugs occur locally in some beds towards the top of the formation near Three Mile Pond.

The sedimentological characteristics of the formation suggest that it was deposited in shallow peritidal conditions.

ORDOVICIAN CARBONATE ROCKS

Unit 5

Unit 5 (Watts Bight Formation, Knight, 1978) consists of an estimated 90-100 m of massive, thick-bedded, black to dark gray, epigenetic, frequently cherty dolomites. The formation is best exposed on the New Ferolle and Castors Point Peninsulas in the north of the area. It also outcrops on the north shore and inland of Hawkes Bay and in the vicinity of Barr'd Harbour. At South Cove it overlies unit 4 conformably, but at Hawkes Bay the base of the formation is faulted.

The dark-colored dolomites are generally thick-bedded, massive and bituminous and characterized by a light gray to white mottling. Original structures include large stromatolite mounds, intense bioturbation and poorly preserved gastropods and straight cephalopods. Intercrystal and cavity porosity (Choquette and Pray, 1970) is well developed and locally filled by buff-colored geopetal dolomitic mudstone.

Unit 6

Unit 6 (Unnamed Unit, Knight, 1978; Boat Harbour Formation, Knight, 1980) consists of two lithological sequences. The lower sequence (6a) consists of approximately 32-50 m of dark to light gray epigenetic dolomites, rare beds of blue-gray and white limestones and extensively developed collapse breccias. The upper sequence (6b) contains 105 m of cyclically developed gray limestone and buff weathering, light gray dolostone or dolomitic limestone.

The lower sequence sits conformably upon unit 5, the contact placed either at the base of a series of dolomite and chert breccias or at a bed of finely laminated, mudcracked, buff-gray dolomite observed near Bartlett's Harbour and at Castors Point. Above the base, the sequence consists of thick- and thin-bedded, white to brown weathering, light to dark gray, very fine to medium crystalline dolomites. White and pink sparry dolomite is common and outlines various secondary diagenetic, solution and structural textures. Locally, limestone beds are preserved and include bioturbated fossiliferous wackestones and packstones, stromatolitic limestones, intraformational breccias, rare thin oolitic grainstones and mudcracked, laminated and flaser-bedded lime mudstones and/or dolostones. Some beds are exceptionally rich in the gastropod *Lecanospira*. Other fossils include inarticulate and orthid brachiopods, silicified straight cephalopods and trilobites. Beds of laminated and structureless, pebbly and sandy dolostones, in a 2.37 m thick interval, occur on the south shore of Squid Cove. The pebbles and sand consist of gray chert, white quartz and dolomite.

Highly variable bedding attitudes and coarse breccias laterally replacing bedded lithologies suggest that widespread solution collapse affected the lower sequence of unit 6. These features are best exposed in the coastal sections north of Fish Point, on the Castors Point peninsula and near Lossieux Point, Hawkes Bay.

The upper limestone-dominated sequence lies apparently conformably upon the lower; undulose bedding at the base of the sequence may reflect molding of basal limestones over the irregularities of the top of the lower sequence. The upper sequence commences with 3 m of thin-bedded limestones with shale drapes. These limestones exhibit numerous structures including wrinkle marks, rill marks, ripple marks, small boundstone mounds and mudcracks. Overlying this unit, the succession consists of cyclic shoaling-upward sequences 1 to 5 m thick of bioturbated wackestones and packstones and flaser-bedded and/or laminated dolomitic lime mudstones or dolostones and thick sequences of bioturbated wackestones with packstone lenses. Intraformational conglomerates may occur locally at the base of some cycles; other cycles contain boundstone mounds including stromatolites and thrombolites; mudcracks are common at the top of several cycles.

Twenty-four to thirty metres from the top of the formation, the succession is extensively dolomitized for some 10 to 20 m. Two sequences within this interval contain numerous quartz-lined spherical vugs and a solution surface occurs near the top of the second sequence. This stratigraphic interval is best exposed at Barbace Point and is only partially exposed at Old Man Cove. It is probably equivalent to the stratigraphic interval that contains the "pebble bed" and disconformity in the type section of the formation near Boat Harbour (see Knight, 1978).

Above the dolomitized interval, the upper 10 - 11 m returns to limestone. Here, crossbedded and ripple marked, skeletal-intraclastic grainstone beds up to 28 cm thick are common within cyclic sequences of bioturbated, flaser-bedded and laminated limestones and dolomitic limestones. The top of the formation is placed at the top of the last mudcracked, laminated limestone exposed in all sections of the formation.

Fossils recovered from the formation include trilobites, brachiopods, straight cephalopods, eocrinoid debris, ostracods and gastropods. Trilobite faunas collected from the formation this summer establish that a faunal break coincides with the dolomitized interval 24 to 30 m from the top of the formation. This supports the regional extension of the disconformity at this stratigraphic level already established farther north at Boat Harbour (Knight, 1978; Boyce, 1979). Limestones in the lower sequence at Fish Point and in the upper sequence below the dolomitized interval at Old Man Cove have yielded trilobites suggestive of the Early Ordovician Ross-Hintze Zones E and F in Utah and Nevada (see Boyce, this volume). Above the dolomitized interval at Old Man Cove, limestones of the upper 11 to 12 m of unit 6 contains trilobite species that belong to Ross-Hintze Zone G_2 of the Early Ordovician. Zone G_1 is, therefore, apparently absent as has been documented in the same stratigraphic interval at the type section of the formation near Boat Harbour (Knight, 1978, Boyce, 1979).

The sedimentological characteristics of the formation suggests that it was deposited under peritidal conditions that produced repeated shallowing-upward sequences typical of shoreline deposition (James, 1979).

Unit 7

Unit 7 (the Catoche Formation, Knight, 1978) consists of gray limestones (7a) that are replaced towards the top of the formation by epigenetic dolomites (7b), previously mapped as "Diagenetic Carbonates" (see Knight, 1977, 1978). The formation as a whole is calculated to be approximately 105 to 165 m thick, with 32-40+ m of epigenetic dolomite at the top of the formation.

The formation conformably overlies unit 6. It consists dominantly of rubbly weathering, gray, extensively bioturbated, well bedded wackestones containing discrete beds and lenses of packstone, grainstone and intraformational conglomerates. Dolomitic mottling, stylolites and laminated drapes are characteristic of the limestones. Coarser grained beds may exhibit scoured bases, large ripple marks, steived ripple marks and may consist of large crossbeds. The limestones are generally fossiliferous, containing trilobites, orthid and inarticulate brachiopods, high- and low-spired and planispiral gastropods, cephalopods, sponges, eocrinoids, ostracods and receptaculitids. Mounds composed of cryptalgal structures (Pratt and James, 1982) but also hosting sponges and many other metazoan fossils occur as irregular to linear structures at several levels in the formation. The limestones accumulated mostly in an open, subtidal shelf environment.

Epigenetic dolomites (7b) at the top of the formation consist of 1 - 2 m beds of porous to nonporous, dark to light gray, fine to medium crystalline bituminous dolomites. Sparry dolomite is extensively developed, especially in the porous centres of beds, giving 'pseudobreccia' textures (Cumming, 1968). Burrow mottling in the porous dolomites and some thin bedding in the nonporous dolomites are locally noted. No basal contact with the underlying limestones is seen and the upper contact is also hard to define because of poor exposure. At Back Arm, however, the dolomites appear to underlie beds of unit 8 conformably.

An abundant trilobite fauna documented from two sections of the formation indicates it contains species common to the Early Ordovician Ross-Hintze Zones G_2, H and possibly I (Boyce, 1979, this volume; Fortey, 1979).

Unit 8

Unit 8, referred to as the Siliceous Dolomite formation (Knight, 1977) and more recently the Aguathuna Formation (Pratt and James, 1982) apparently conformably overlies unit 7b. In Back Arm, it is 17 m thick compared to 70 to 90 m at Table Point (Levesque, 1977; Knight, 1978). The unit is poorly exposed elsewhere in the map area.

At Back Arm, the unit, which was deposited mainly in an intertidal environment, consists of two parts. The lower 4 m consists of 20 to 50 cm beds of yellow weathering, massive to laminated dolostone with several distinct solution surfaces marking bedding planes; some ripple marks and mudcrack polygons were also observed.

Above the dolostones, the succession is completed by several cycles of mottled, argillaceous, dolomitic lime mudstones and wackestones capped by calcareous dolostones or dolomitic lime mudstones. The mottled wackestones contain ostracods, brachiopods and the trilobite *Bathyurus perplexus* Billings, which indicates the unit is of probable early Middle Ordovician age (Boyce, this volume). The calcic dolostones or lime mudstones may be laminated and some beds contain laminoid fenestral fabrics (Logan, 1974; Grover and Read, 1978).

The unit is extensively replaced by epigenetic dolomites in an irregular fashion on the Point Riche Peninsula and east of Ingornachoix Bay and Port au Choix.

Unit 9

Unit 9, the Table Head Formation of Middle Ordovician age, consists of well bedded, blue-black and rubbly weathering, bioturbated, gray limestones that were deposited in a subtidal, open shelf environment. They are part of an incomplete section approximately 50 m thick and are characteristically thickly bedded, massive and abundantly fossiliferous. Bedding at several levels has been affected by postdepositional mass movement that in some instances has produced extensively brecciated limestones. Crossbedding was noted a few metres above the base of the formation at Gargamelle Cove.

The base of the formation is placed at the base of the first bed of continuous, thick, rubbly-weathering limestone, as earlier proposed by Knight (1977, p. 25). It is exposed at Back Arm and Gargamelle Cove where the base of the formation is conformable. Elsewhere, however, as at Black Point and inland on the Pointe Riche Peninsula and east of Port au Choix, the base of the formation has been dolomitized for many metres up into the unit. The epigenetic dolomites have sharp, irregular to linear contacts with adjacent limestones. Some dolomites are clearly related to nearby faults as for example at Gargamelle Cove where the dolomites form a narrow linear outcrop. The dolomites are pale yellow weathering, light gray to yellowish gray in color and show lighter colored mottling. Porosity is often abundant in the dolomites.

STRUCTURE

In general, the map area is underlain by gently dipping strata that young from north to south. However, the strata are gently warped about northeast trending fold axes, and some tight upright folds have been mapped locally between closely spaced faults. A northeast trending, steeply dipping fracture cleavage is locally developed in the limestones of the area.

Long, northeast trending, straight to gently curved faults which splay and interconnect with each other (Fig. 2) dominate the map area. The Ten Mile Lake Fault is the major structure in the north. There it juxtaposes southwestward-dipping and folded Lower Ordovician strata in the west and southeastward-dipping Lower Cambrian rocks and Precambrian basement in the east, a vertical displacement of at least 1 km. To the south the fault splays to form the Port Saunders, Ingornachoix Bay and Whale Factory Pond Faults. The Port Saunders Fault is apparently the main dislocation, juxtaposing dolomitized rocks of unit 6 in the south and limestones and dolomites of the Table Head Formation (unit 9), a vertical throw to the northwest of approximately 350 to 500 m. Other faults in the south include the Back Arm Fault near Port au Choix and the Big East River Fault which cuts the northeast shore of Hawke Bay. The Big East River Fault is an important splay of a fault that separates the Highlands of St. John terrain from Precambrian basement rocks that form the backbone of the Great Northern Peninsula. In the map area, it downthrows Upper Cambrian dolostone (unit 4) against the Hawke Bay and Forteau Formations (units 2b and c), a vertical throw to the northwest of 50 to 100 m.

The fault zones are exposed at Port Saunders, in a quarry near Greta Gulch and on the north shore of Hawkes Bay. They vary from intensely shattered and locally brecciated zones several metres wide to sharp, planar surfaces. Dolomite commonly replaces limestones adjacent to the faults. Vertical, oblique and horizontal slickensides have been noted along the faults, and gentle to tight drag folds with locally inverted bedding may be developed close to the faults.

Northwest trending faults of lesser importance also occur in the area at Barbace Cove and just north of Barr'd Harbour. A northwest trending fault is also inferred to strike along Keppel Harbour. Minor northwest trending folds are associated with the faults, and horizontal as well as vertical slickensides have been noted. These faults commonly offset minor northeast trending faults.

The main northeast trending faults are all downthrown to the northwest, suggesting that they are normal faults. Vertical slickensides and local drag folds support this sense of movement. However, where major faults such as the Port Saunders, Ten Mile Lake and Big East River Faults are crossed, the distribution of rock units indicates that stratigraphic rock boundaries northwest of the faults are displaced tens of kilometres to the northeast. This suggests that right-lateral strike-slip movements have also affected the succession, as indicated locally by slickensiding.

ECONOMIC GEOLOGY

The area contains no known economic mineral deposits. Massive to disseminated pyrite was noted in limestones, dolomites and collapse breccias in unit 6. Fluorite occurs in vugs in the dolostones and limestones of unit 6 and also as disseminations in the limestones.

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PRELIMINARY ORDOVICIAN TRILOBITE BIOSTRATIGRAPHY OF THE EDDIES COVE WEST - PORT AU CHOIX AREA, WESTERN NEWFOUNDLAND

by

W.D. BOYCE

INTRODUCTION

The Cambrian-Ordovician carbonate deposits of the Great Northern Peninsula are the object of a continuing regional taxonomic-biostratigraphic study aimed at correlating western Newfoundland trilobite faunas with the standard Cambrian and Ordovician trilobite zonal schemes of North America (Palmer, 1977; Ross, 1951; Hintze, 1953). This report focusses on new Ordovician trilobite collections obtained by the author in September 1982 while acting as field assistant to Knight (this volume), who measured detailed lithostratigraphic sections in the Eddies Cove West - Port au Choix area. Close to one hundred fossiliferous horizons were sampled for trilobites. The information obtained by the author expands, updates and modifies the work of Boyce (1978, 1979, in preparation) and Fortey (1979) and allows their respective biostratigraphic sections to be linked for the first time. In addition, the faunal gap recorded by Boyce (1978, 1979, in preparation) at Boat Harbour is now shown to be recognizable at Eddies Cove West as well.

LITHOSTRATIGRAPHY

See Knight (this volume) for a detailed discussion of the lithostratigraphy. Of interest here are Ordovician rock units belonging to the Boat Harbour, Catoche and Aguathuna Formations (Units 6, 7 and 8, Knight, this volume) of the St. George Group.

BIOSTRATIGRAPHY - THE SEQUENCE OF TRILOBITE FAUNAS

Unit 6

Along the coast south of Squid Cove and north of Fish Point, beds assigned to Unit 6 have yielded the trilobite *Hystricurus oculilunatus* Ross (1951) in association with rare straight cephalopods and the planispiral gastropod *Lecanospira*. *Hystricurus oculilunatus* Ross and *Lecanospira* have also been obtained from a roadside quarry along the Viking Trail, 4 km north of the junction with the road to Port Saunders.

At Fish Point, Unit 6a has yielded the trilobites *Parahystricurus* cf. *P. carinatus* Ross (1951) and *?Paraplethopeltis* sp.. The species *Parahystricurus carinatus* Ross occurs in the Early Ordovician Ross-Hintze Zone E in Utah (Ross, 1951).

In the vicinity of Eddies Cove West at Old Man Cove, an incompletely exposed dolomitized interval occurs near the top of Unit 6b. In the equivalent sequence at Barbace Point, Port au Choix Peninsula, Knight (this volume) has identified two sequences that contain numerous white to vitreous blue quartz- lined spherical vugs. A solution surface has also been identified at the top of the second sequence. This dolomitized interval is believed to be stratigraphically equivalent to that in Boat Harbour containing the "pebble bed" disconformity of Knight (1977, 1978, 1980), Boyce (1978, 1979, in preparation) and Stouge and Boyce (in press).

In Eddies Cove West, twenty-one fossiliferous horizons were sampled in Unit 6b below the Old Man Cove dolomitized interval. The following trilobites were obtained: *Hystricurus* sp. nov. 1 (Boyce, in preparation), *"Parabellefontia"* sp. (Boyce, in preparation), *Hystricurus oculilunatus* Ross, *Parahystricurus* sp. nov. (Boyce, in preparation), *Leiostegium* sp. nov. (Boyce, in preparation), *Tesselacauda* cf. *T. depressa* Ross *sensu* Demeter (1973), *Paraplethopeltis seelyi* (Whitfield, 1889), *Hystricurus* sp. nov. 2 and *Hyperbolochilus* sp. nov. (Boyce, in preparation). Associated with these trilobites were brachiopods (*Diaphelasma*, orthids), cephalopods (*Bassleroceras*), echinoderms (eocrinoid debris) and gastropods (*Ecculiomphalus*, *Lecanospira*). The same fauna occurs below the Boat Harbour "pebble bed". *Hystricurus oculilunatus* Ross occurs in Early Ordovician Ross-Hintze Zones E and F in Utah (Ross, 1951; Hintze, 1953; Terrell, 1973) while *Tesselacauda depressa* Ross *sensu* Demeter is apparently restricted to Zone E (Demeter, 1973).

Above the Old Man Cove dolomitized interval, four fossiliferous horizons were sampled in Unit 6b. The following trilobites were collected: *Bolbocephalus* sp. nov. 1 (Boyce, in preparation), *Isoteloides peri* Fortey (1979), *Bolbocephalus convexus* (Billings, 1865), *Benthamaspis* sp. nov. (Boyce, in preparation; the same species as unassigned pygidium of Hintze, 1953; pl. XV, figs. 18a,b), *Hystricurus* sp. nov. 3 (possibly the same species as undetermined pygidium of Hintze, 1953; pl. XX, figs. 14a,b), *Bathyurina* sp. nov. (Boyce, in preparation; the same species as Genus et sp. indet. II of Poulsen, 1946; pl. XXIII, fig. 10 only) and *Bathyurellus abruptus* Billings (1865). The species *Benthamaspis* sp. nov. (Boyce, in preparation) occurs in the Early Ordovician Ross-Hintze Zone G_2, as possibly does *Hystricurus* sp. nov. 3. On the north side of Barbace Cove on the Port au Choix Peninsula, six fossiliferous horizons from this interval yielded only *Isoteloides peri* Fortey.

The Significance of the Old Man Cove Dolomitized Interval

The incompletely exposed Old Man Cove dolomitized interval separates Zone E-F and Zone G_2 trilobite faunas. Zone G_1 faunas are apparently absent, as is the case farther north in the Boat Harbour area where the "pebble bed" disconformity of Knight (1977, 1978, 1980), Boyce (1978, 1979, in preparation), and Stouge and Boyce (in press) also separates Zone E-F and Zone G_2 trilobite faunas. The magnitude of the faunal gap may be different in Eddies Cove West, however.

Unit 7

In the Eddies Cove West area, forty-one fossiliferous horizons were sampled in Unit 7 and the following trilobites obtained: *Isoteloides peri* Fortey, *Bolbocephalus convexus* (Billings), *Hystricurus* sp. nov. 3, *Bathyurina* sp. nov. (Boyce, in preparation), *Bathyurellus abruptus* Billings, *Peltabellia* cf. *P. willistoni* Lochman (1966), *Petigurus* cf. *P. groenlandicus* Poulsen (1937), *Uromystrum affine* (Poulsen, 1937), *Petigurus nero* (Billings, 1865), *Grinnellaspis* sp. nov. (Boyce, in preparation), *Benthamaspis* sp. undet., *Ischyrotoma* sp. undet., *Benthamaspis conica* Fortey (1979), *Strigigenalis caudata* (Billings, 1865), *Isoteloides latimarginatus* Fortey (1979), *Punka flabelliformis* Fortey (1979), *Ischyrotoma anataphra* Fortey (1979), *Uromystrum* sp. nov. 1, *Bathyurina timon* (Billings, 1865), *Catochia ornata* Fortey (1979), *Strotactinus insularis* (Billings, 1865), *Benthamaspis gibberula* (Billings, 1865), *Bolbocephalus* sp. nov. 2 (= Genus et sp. ind. Poulsen, 1937; pl. 8, fig. 2), *Uromystrum* sp. nov. 2 (Boyce, in preparation; = *Uromystrum* cf. *affine*, Fortey, 1979), *Bathyurellus platypus* Fortey (1979), and *Catochia glabra* Fortey (1979). A Ross-Hintze Zone G_2 age is suggested by the species *Hystricurus* sp. nov. 3 (Boyce, this report) and *Benthamaspis conica* (Fortey, 1979, p. 102). A Zone H age is also indicated by the presence of *Benthamaspis gibberula* (Billings), which Fortey (1979, p. 101-102) has identified from that zone in Utah (i.e. *B. distinctus* Young, 1973, p. 98; pl. 1, figs. 9-17).

On the north side of Barbace Cove on the Port au Choix Peninsula, seven fossiliferous horizons were sampled in

Unit 7. The following trilobites were collected: *Isoteloides peri* Fortey, *Benthamaspis* sp. nov. (Boyce, in preparation), *Ischyrotoma* sp. undet., *Hystricurus* sp. nov. 3, *Bathyurina* sp. nov. (Boyce, in preparation), *Bolbocephalus convexus* (Billings), *Peltabellia* cf. *P. willistoni* Lochman, *Grinnellaspis* sp. nov. (Boyce, in preparation), *Petigurus* cf. *P. groenlandicus* Poulsen, *Petigurus nero* (Billings), *Benthamaspis conica* Fortey and *Strigigenalis caudata* (Billings). The species *Hystricurus* sp. nov. 3, *Benthamaspis* sp. nov. (Boyce, in preparation) and *Benthamaspis conica* Fortey suggest only a Ross-Hintze Zone G_2 age for the rocks exposed here. On the south side of Barbace Cove, however, Fortey (1979, p. 63, fig. 11) has identified in Unit 7 the Zone H species *Carolinites genacinaca nevadensis* Hintze (1953) and *Benthamaspis gibberula* (Billings). Here, Fortey (1979) sampled thirteen fossiliferous horizons.

Unit 8

At Back Arm in Port au Choix, Unit 8 has yielded the trilobite *Bathyurus perplexus* Billings (1865) of probable early Middle Ordovician age. It was previously unknown from this locality.

SUMMARY

Below the incompletely exposed dolomitized interval in the Eddies Cove West - Port au Choix area, Unit 6 is of Early Ordovician Ross-Hintze Zone E-F age. Above this interval, however, Unit 6 is of Early Ordovician Zone G_2 age. Zone G_1 trilobite faunas are apparently absent, as is the case farther north in the Boat Harbour area. The magnitude of the faunal gap in the Eddies Cove West - Port au Choix area may be different, however. Unit 7 is of Early Ordovician Ross-Hintze Zone G_2-H age and Unit 8 is, at least in its uppermost part, of probable early Middle Ordovician age.

The information obtained by the author from the continuous Eddies Cove West section will allow a comprehensive Ordovician trilobite biostratigraphic zonation for western Newfoundland to be erected from the non-overlapping biostratigraphic sections of Boyce (in preparation) and Fortey (1979).

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Geology of the east half of the Cold Spring Pond map area (12A/1), Newfoundland

by

S.P. Colman-Sadd

Introduction

During 1982, 1:50,000 scale mapping has been done in the part of the Cold Spring Pond area that is easily accessible from the road servicing the Upper Salmon River hydroelectric development. Together with the mapping of Swinden at the 1:20,000 scale (Swinden, 1981; Swinden and Collins, 1982), this year's work has resulted in detailed coverage of slightly more than half of the entire map area (Figure 1). Eastwards it connects with 1:50,000 scale mapping in the Twillick Brook area (2D/4) (Colman-Sadd, 1980a) and southwards with 1:50,000 scale mapping in the D'Espoir Brook area (11P/16) (Dickson and Tomlin, 1983). This report deals only with units that have been mapped during 1982. For descriptions of other units in the north of the area, which appear on the map but not in the text, the reader is referred to Swinden and Collins (1982).

Previous work in the Cold Spring Pond area has been reviewed by Colman-Sadd and Swinden (1982), and their report places it within the general context of the geological exploration of south-central Newfoundland. The first investigations were those of Murray (Murray and Howley, 1881) when he ascended the Salmon River system through Round Pond and the North Salmon River. Work done by the Buchans Mining Company during the 1950's has been summarized in the maps of Swanson (1952-1960); a study that is particularly relevant to the present project is a thesis by Slipp (1952) that was sponsored by the company, and which describes Round Pond and the adjacent area to the west. Exploration was done by the Hansa Syndicate in the northern part of the area during the late 1960's (Sander and Owen, 1968; Sander, 1969; Sander and Heshka, 1970); it involved both bedrock mapping and geophysical surveys. This work was followed up by Consolidated Morrison and Riocanex between 1975 and 1980 (Harris, 1976; Bucknell *et al.*, 1976; Bucknell, 1977; Bucknell and McKenzie, 1977a, b; Harris, 1980). Regional studies that have included the Cold Spring Pond area are the 1:250,000 map series of the Geological Survey of Canada (Williams, 1970), and the lake sediment geochemistry survey of the Newfoundland Department of Mines and Energy (Butler and Davenport, 1978).

Two main divisions of stratified rocks outcrop in the area. These are the North Steady Pond Formation in the north and west and the Salmon River Dam Formation in the south and east. Both formations are included in the Baie d'Espoir Group which is considered to be Lower to Middle Ordovician in age (Colman-Sadd, 1980b). Both formations have been polydeformed and, although mainly metamorphosed in the greenschist facies, locally show sharp metamorphic gradients up to migmatite. Migmatites form a domal structure around White Hill and, to the west, a concordant belt along the southern edge of the North Steady Pond Formation. A large body of

Contribution to Canada-Newfoundland co-operative mineral program 1982-84. Project carried out by Newfoundland Department of Mines and Energy.

gabbro and diorite separates the migmatites from the outcrop of Salmon River Dam Formation in the south of the area, and gabbro also occurs at Round Pond. Biotite and biotite-muscovite granite occurs in the southeast corner of the area where it has intruded the White Hill migmatite and the Salmon River Dam Formation; it forms part of the North Bay Granite batholith (Jewell, 1939; Colman-Sadd, 1980b; Dickson and Tomlin, 1983). At the western limit of mapping there are isolated exposures of foliated megacrystic granite and quartz-rich migmatitic sedimentary rocks; further mapping is necessary to determine the relationships of these rocks to the other units.

SALMON RIVER DAM FORMATION (Unit 5)

Part of unit 5 is physically continuous with the Salmon River Dam Formation as mapped in the Twillick Brook (2D/4) and St. Albans (1M/13) areas (Colman-Sadd, 1976, 1980a). The outcrop south and west of Ahwachenjeesh Pond is separated from the main outcrop by granite and migmatite, but has the same lithologic characteristics. The unit is divided into a mainly medium to thick bedded variety (unit 5a) and a thin bedded variety (unit 5b). The latter can be separately mapped in the area of Godaleich Pond, where it appears to be transitional into thinly bedded and more argillaceous rocks of the North Steady Pond Formation. Elsewhere it occurs as a minor and unseparated component within the medium to thick bedded unit.

Rocks of unit 5a are composed mainly of quartzo-feldspathic siltstone and very fine grained sandstone in beds between 10 cm and 1 m thick. On fresh surfaces the rock is dark purplish gray and weathers light brown. The beds are mostly massive, but in a few there are faint diffuse parallel laminations of light green siltstone. A number of different kinds of thin interbeds occur. The most common of these are medium grained, purplish gray sandstone beds, 1 to 10 cm thick, with sharply defined tops and bases, cross laminations and load casts. Pelitic and semipelitic beds, 1 to 5 cm thick, are also common throughout the unit. Calc-silicate beds are a very distinct component of most parts of the unit; they are especially common west of Ahwachenjeesh Pond where they locally form up to 20 per cent of the rock. The beds consist of a white, medium grained matrix of quartz, plagioclase and clinozoisite, with disseminated needles of dark green actinolite. They are generally 1 to 5 cm thick and either massive or cross laminated. Light green quartzite occurs locally forming massive beds 3 to 30 cm thick; in an exceptional occurrence south of Round Pond this rock type is the only one represented in a series of exposures along 1.5 km of shoreline.

Unit 5b is composed of fine to medium grained purplish gray sandstone, interbedded on a scale of 1 to 10 cm with massive dark gray siltstone. The sandstone beds are characterized by well defined parallel and cross laminations. Minor pelitic and semipelitic beds are present, but calc-silicate and green quartzite beds are absent.

Most of the Salmon River Dam Formation has been metamorphosed in the greenschist facies and metamorphic biotite is visible in hand specimens of the siltstone and sandstone. Close to the North Bay Granite (unit 17) the formation contains porphyroblasts of biotite and chlorite, and there are chloritized spots that are thought to have been originally cordierite (Colman-Sadd, 1980a, p. 14). Exposures along the road within the outcrop of the White Hill migmatite (unit 14) have coarse biotite growth and contain quartz and granite segregations. Segregations are also present in some exposures on the west shore of Round Pond where the sediments are intensely deformed and contain discordant and concordant intrusions of foliated biotite granite.

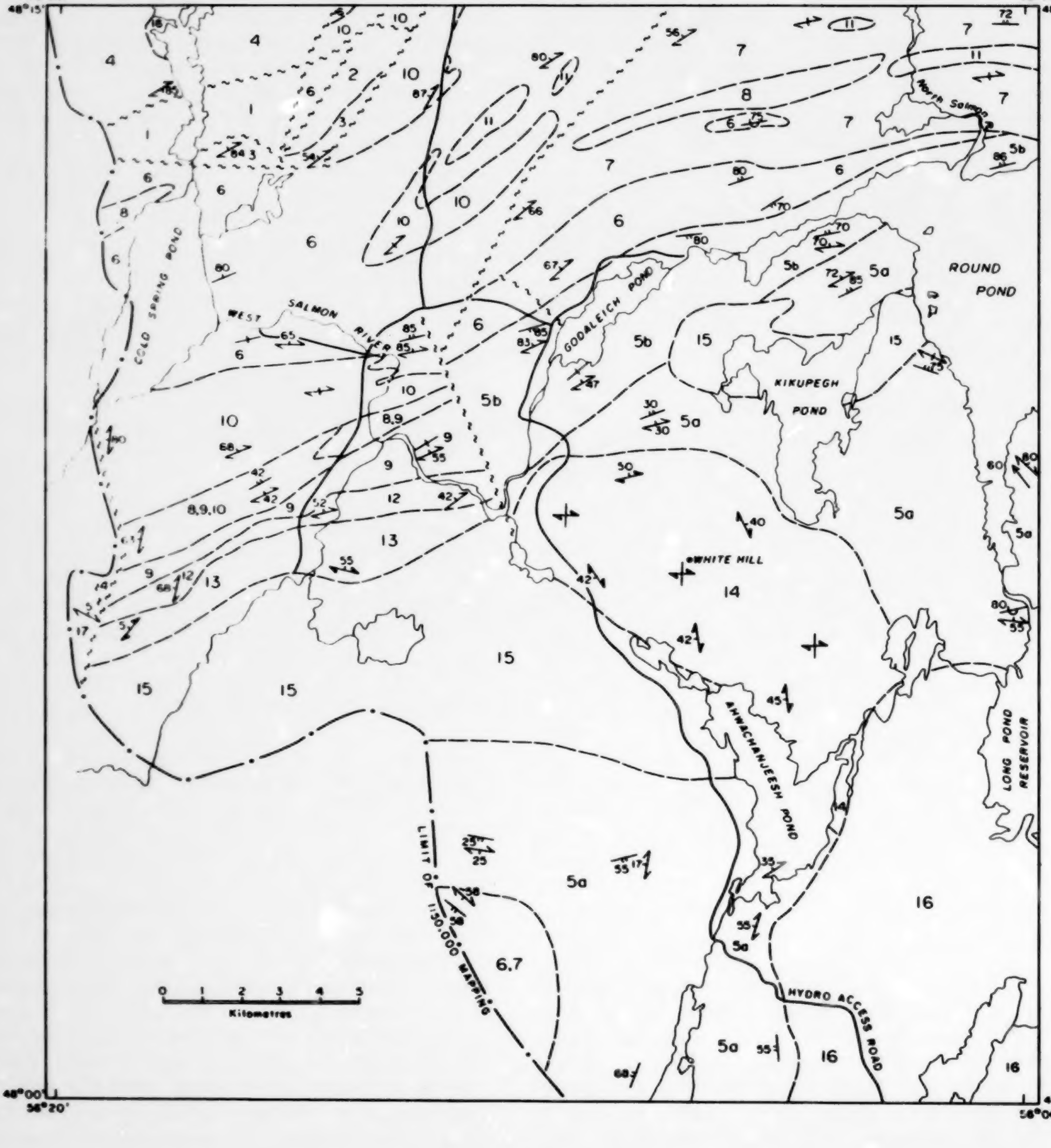

Figure 1: Geological sketch map of the eastern part of the Cold Spring Pond area. Note that information north of Godaleich Pond is simplified from Swinden (1981); only the area from Godaleich Pond southwards has been mapped during 1982 and is the subject of this report.

DEVONIAN OR OLDER

17 Foliated, megacrystic, biotite granite.

16 Equigranular to porphyritic, medium to coarse grained, biotite or biotite-muscovite granite. Includes North Bay Granite.

15 Gabbro, diorite and minor granodiorite.

14 Well foliated, medium to coarse grained migmatite, with schlieren structure.

13 Diffusely banded muscovite-biotite granite and migmatitic schist.

12 Psammitic schist with quartz and granite sweats.

LOWER TO MIDDLE ORDOVICIAN

Baie d'Espoir Group (no stratigraphic order implied by sequence)

North Steady Pond Formation and related units

11 Mafic pillow lava, massive basalt, pillow breccia. Includes considerable fine grained chloritic tuff and lesser fine grained sediments.
10 Silicic pyroclastic rocks; dark green to black, siliceous tuff with abundant quartz crystals and local concentrations of feldspar crystals and/or lithic fragments.
9 Dark green thinly bedded phyllite.
8 Conglomerate; polymictic, unstratified to poorly stratified boulder and pebble conglomerate; commonly matrix supported and poorly sorted.
7 Silicic tuff and reworked tuff, quartz and feldspar crystal tuff and crystal-lithic tuff; commonly unstratified but locally shows evidence of reworking.
6 Sedimentary rocks; includes gray to green, thick to thin bedded, arkosic sandstone, siltstone and laminated phyllite, with local, black, graphitic argillite.

5 **Salmon River Dam Formation**: Dark purplish gray siltstone and very fine grained sandstone, with minor calc-silicate, pelitic and quartzitic beds. 5a mainly medium to thick bedded; 5b thin bedded.

ORDOVICIAN OR OLDER

4 Psammitic to semipelitic schist and paragneiss.

CAMBRIAN TO LOWER ORDOVICIAN

3 Basalt; pillowed to massive flows, commonly variolitic, pillow breccia, minor tuff.

2 Coarse to medium grained gabbro and trondhjemite, with minor pyroxenite.

1 Peridotite; fine grained, commonly with pyroxene phenocrysts and disseminated chromite.

The first deformation of the Salmon River Dam Formation formed pervasive tight folds. A related axial planar cleavage is clearly seen in pelitic and semipelitic interbeds, but is poorly developed in the siltstone and sandstone beds that are the dominant rock type. In the outcrop south and west of Ahwachenjeesh Pond the folds are recumbent with a gently dipping cleavage and gently plunging axes. The strike of beds and cleavage tends to follow the boundaries of the adjacent igneous and metamorphic rocks. At the south end of Round Pond the axial planar cleavage dips moderately to the north and the folds, which face upwards, have overturned limbs towards the south and plunge moderately to the east. Northwards, away from the North Bay Granite contact, the strike and plunge become more northerly. Unit 5b, at Godaleich Pond and northern Round Pond, has a cleavage that dips moderately northwest, and forms folds that plunge gently to the northeast and are overturned to the southeast; exposures in the West Salmon River, southwest of Godaleich Pond show complex chaotic folding. Second deformation structures are most easily seen in the thin bedded rocks of unit 5b, where they form crenulations of the bedding and early cleavage.

NORTH STEADY POND FORMATION
(Units 6,8-10)

Rocks which are provisionally assigned to the North Steady Pond Formation outcrop southeast of Cold Spring Pond and are along strike from rocks described by Swinden and Collins (1982). Similar rock types also occur southwest of Ahwachenjeesh Pond, but further mapping is required to establish how these relate to the geology of the area as a whole. The North Steady Pond Formation is characterized by volcanic rocks, which in the area described in this report are exclusively felsic crystal and lithic tuffs. Associated with the volcanic rocks are metasedimentary rocks ranging from phyllite to conglomerate. The contact between the North Steady Pond and Salmon River Dam Formations is exposed in the tailrace immediately northwest of Godaleich Pond. The small scale structure is so complicated, however, that it has obscured the original relationships of the two formations and although they appear to have been conformable, their stratigraphic order is uncertain.

Unit 6 consists of dark gray phyllite, siltstone and sandstone that weather light green. The sandstone is arkosic and forms graded beds 1 to 2 cm thick; close to the contact with unit 10 some of the beds are massive and contain prominent quartz crystals similar to those in the tuff of unit 10. The sandstone is interbedded with 2 to 3 cm beds of phyllite containing parallel laminae of siltstone.

Tuff of unit 10 forms a homogeneous outcrop, immediately southeast of Cold Spring Pond, that narrows towards the northeast and appears to pass laterally into unit 6. South of this homogeneous zone is a belt in which tuff (unit 10) is mixed with conglomerate (unit 8) and green phyllite (unit 9). The tuff is dark gray, unbedded and fairly well cleaved. Quartz crystals up to 2 mm across form up to 10 per cent of the rock, and there are also smaller amounts of feldspar crystals and disseminated grains of pyrite. At the southern boundary of unit 10, in the West Salmon River, there has been sericitic alteration and the rock weathers mostly brown instead of the more usual white. In the zone where tuff is interbedded with conglomerate, it contains lithic fragments and there is some difficulty in making a distinction between the two rock types. One particularly good exposure of probable lithic tuff is essentially unbedded and consists mainly of crystals and flat felsic volcanic fragments between 1 mm and 1 cm across; exceptional fragments are as long as 5 cm with a maximum thickness of about 1 cm. Rare accidental fragments of granite are rounded, unflattened and form augen within the fabric. In the West Salmon River, felsic volcanic rocks are absent from this horizon which is composed entirely of interbedded conglomerate and phyllite. The phyllite is dark green and beds are defined by dark, slightly more pelitic, 1 to 5 mm laminae between the 1 to 5 cm beds of the dominant rock type; locally thin siltstone beds occur.

Metamorphism of the North Steady Pond Formation was in the greenschist facies except in a southwest trending zone adjacent to the linear outcrop of migmatite (units 12-13). Across the zone, which is about 2 km wide, there is a rapid increase in grade, from rocks containing first chlorite porphyroblasts and then andalusite in semipelitic compositions, to migmatite and granite. Exposures of psammitic schist with granitic segregations (unit 12) in the southernmost bend of the West Salmon River are thought to have been originally felsic tuff because of their unbedded nature and the presence of what may be relict quartz crystals.

The structural history of the North Steady Pond Formation is similar to that of the Salmon River Dam Formation. The first deformation formed a penetrative cleavage in most rock types and bedding has been tightly or isoclinally folded. The cleavage dips steeply to the northwest except at the western edge of the outcrop where it appears to parallel an assumed fault extending south from Cold Spring Pond. Bedding-cleavage intersection lineations plunge gently to the northeast. Second deformation structures are limited to steeply plunging crenulations and vertical kink bands.

MIGMATITES (Units 12-14)

Migmatitic rocks form two areas of outcrop that may or may not be genetically related. The first of these is the narrow zone of migmatized metasedimentary rock and granite at the southern edge of the North Steady Pond Formation (units 12, 13). The second is the elliptical outcrop of migmatite that is centered on the White Hill (unit 14).

The progressive southward metamorphism of the North Steady Pond Formation has produced thin concordant quartz and granite sweats in the largely unbedded psammitic schist (unit 12) that extends across the south lobe of the West Salmon River. Where the unit is exposed farther to the southwest across the river's tributary, the sweats can be seen to increase in size from 1 mm lenses into sheets of biotite granite up to 15 cm thick, until the metasediment has become completely pervaded by granite and is a foliated migmatite. Exposures within about 1 km of the contact with the gabbro/diorite of unit 15 vary from a diffusely banded muscovite-biotite granite (nebulitic migmatite of Mehnert, 1971) to a quartz-biotite schist with an interfolial migmatitic matrix (unit 13). A fabric defined by mica orientations parallels the banding which locally is isoclinally folded. The migmatite contains sheets of black carbonaceous schist and abundant xenoliths of psammitic schist, finely banded psammite and quartzite, massive gabbro, epidote and tremolite-talc schist.

The migmatite around the White Hill is more homogeneous than that at the edge of the North Steady Pond Formation even though it underlies a greater area. There is no section that shows a clear metamorphic gradation from surrounding low grade rocks, either because the gradation does not exist, or else, as is more likely, because it is unexposed. The Salmon River Dam Formation which forms most of the country rock shows incipient migmatization farther east at the western edge of Round Pond and also in isolated exposures of the formation within the main White Hill migmatite outcrop. It is possible, therefore, that the migmatite has been derived by ultrametamorphism of this formation. Typically the rock consists of coarse grained biotite foliae or schlieren (Mehnert, 1971) spaced 2 mm to 5 cm apart in a granite leucosome. The foliae define complex flow folds and intrafolial isoclines are present in some exposures. The leucosome is medium grained equigranular biotite-muscovite granite with disseminated tourmaline. The migmatite contains xenoliths, up to 1 m across, of foliated amphibolite, as well as xenoliths and screens of psammitic and semipelitic schist some of which appear to be bedded. Some of the xenoliths are folded or boudinaged and their foliations may be strongly discordant with that in the migmatite itself. The semipelitic schist locally contains sillimanite porphyroblasts. Dikes of muscovite-garnet-tourmaline granite, aplite and pegmatite crosscut many of the exposures and quartz veins are common. Measurements of the gross orientation of the migmatite foliation show that it is generally flat in the centre of the outcrop, and that it dips at moderate angles towards all the contacts, except for that in the southeast with the North Bay Granite. The entire outcrop has the form of an elongated dome.

GABBRO/DIORITE (Unit 15)

Two intrusions of gabbro, diorite and very minor granodiorite have been mapped in the area. The first of these, at Kikupegh and Round Ponds, is probably continuous with the Round Pond Gabbronorite of Colman-Sadd (1980a). It is interpreted as intrusive into the Salmon River Dam Formation although no actual contacts are exposed. The second intrusion stretches west from Ahwachenjeesh Pond and the edge of the White Hill. It is bordered on the south by the Salmon River Dam Formation and on the north by migmatite of unit 13; the natures of the contacts are unknown because none are exposed. Likewise the contact with the White Hill migmatite (unit 14) may be a fault or may be intrusive; if the latter is the case, it is not known which unit is intrusive into which. It is possible that the two mafic intrusions were originally one and have been split apart by diapiric emplacement of the White Hill migmatite. The northeasterly intrusion and the migmatite are separated by an area of no exposure which could be underlain by gabbro, although it is not interpreted to be so on the map. Furthermore, mafic xenoliths are a characteristic component of the migmatite terrain. The xenoliths, however, are commonly foliated and do not bear a striking resemblance to either of the mafic intrusions.

Both intrusions consist mainly of gabbro composed of plagioclase, hornblende, biotite and accessory pyrite; the hornblende:biotite ratio varies considerably and, locally, substantial amounts of quartz are present. The rock is light to dark greenish gray, medium grained, equigranular and massive. A tectonic fabric is only rarely present; in the west intrusion it is either a horizontal lineation or a flat planar fabric, whereas the intrusion at Round Pond is cut by several steeply dipping shear zones that appear to be related to the regional structure. The west intrusion varies from gabbro to granodiorite but within any one exposure is homogeneous; the Round Pond intrusion, however, consists entirely of gabbro, but within single exposures different phases, distinguished by grain size, show intrusive contacts. Both intrusions contain small clots of biotite and hornblende as well as xenoliths of biotite psammite, amphibolite and coarse pyroxenite; the largest xenoliths are a metre across. Both intrusions are also commonly cut by quartz-feldspar-tourmaline veins, generally 10 cm or less in width; veins of gabbro aplite and pegmatite, the latter with 5 cm long hornblende crystals, occur in some parts of the west intrusion.

NORTH BAY GRANITE (Unit 16)

The North Bay Granite outcrops in the southeastern corner of the map area. It forms part of a batholith that extends south into the D'Espoir Brook area (11P/16) (Dickson and Tomlin, 1983), east into the Twillick Brook area (2D/4) (Colman-Sadd, 1980a) and southeast into the St. Albans area (1M/13) (Colman-Sadd, 1976).

No contacts between the granite and surrounding rocks have been observed in the Cold Spring Pond area. The granite, however, is quite clearly intrusive into the Salmon River Dam Formation from evidence outside the area (Colman-Sadd, 1980b) and from the increase in metamorphism of the formation close to the contacts. Garnet-tourmaline-muscovite granite veins that cut the granite and appear to be genetically related to it also form an integral part of the White Hill migmatite terrain (unit 14).

The granite has two main phases which appear to be gradational into each other. At the southern edge of the area is a porphyritic granite, in which white potassium feldspar phenocrysts are set in a medium grained equigranular matrix of biotite granite. The phenocrysts have square or rectangular cross sections with dimensions up to 10 cm by 5 cm, and in many places there is a slight preferred orientation. Northwards the proportion of phenocrysts decreases and muscovite occurs as a primary constituent of the granite in some exposures. Occurrences of the granite east of Ahwachenjeesh Pond are all equigranular and contain both muscovite and biotite.

FOLIATED MEGACRYSTIC GRANITE (Unit 17)

South of Cold Spring Pond, two exposures of foliated, megacrystic, biotite granite occur along strike from rocks of the North Steady Pond Formation and its migmatized equivalents. The granite is assumed to be separated from the metasedimentary rocks by a fault since there is no indication from veining or metamorphism that there may be an intrusive contact. Mapping during 1982 has only been sufficient to indicate the presence of this unit; its extent and true relationships to the other units may become clear with further work.

MINERAL POTENTIAL

The rocks with the most obvious potential for economic mineral deposits in the area are the volcanic units of the North Steady Pond Formation (units 6,8-10). Mapping during 1982 has extended detailed coverage of the formation a few kilometres farther to the southwest, but has not added any new metallogenic information. The reader is therefore referred to Swinden and Collins (1982) for a discussion of the economic geology of these rocks and in particular for information on their relationship to the pyrrhotite-chalcopyrite mineralization farther to the north at Great Burnt Lake. The most significant discovery with regard to the volcanic rocks in the Cold Spring Pond area is that they also occur near its southern edge; only a few exposures have been visited and these are at the extreme limit of mapping, but they do indicate that there may be significant outcrops of volcanic rocks in country that has not previously been regarded as having high potential.

The North Bay Granite (unit 16) gives no indication of mineralization, but it should be remembered that the same batholith is mineralized at Granite Lake, 70 km to the west (Dickson and MacLellan, 1981). The migmatites (units 12-14) likewise are unmineralized except for widespread disseminations of pyrite; the best potential is in units 12 and 13 which may have been derived from volcanic rocks and which could, therefore, have inherited metamorphosed massive sulphide deposits. There is no indication that the Salmon River Dam Formation (unit 5) and the gabbro/diorite intrusions (unit 15) are anything but barren.

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GEOLOGY OF THE FACHEUX BAY (11P/9) MAP AREA, NEWFOUNDLAND

by

R. Frank Blackwood

INTRODUCTION

The Facheux Bay (11P/9) map area is located around, and west of, the entrance to Bay d'Espoir on Newfoundland's south coast. It is accessible by small boat out of St. Alban's and Hermitage, the two closest road links. McCallum, the only community in the area, is a regular stop on CN Marine's south coast ferry run.

Nearly all of the land mass lies in the northern part of the map area; a small portion of the Hermitage Peninsula occurs in the southeastern corner. Mapping on a 1:50,000 scale was completed in the northern part during the 1982 field season. Almost continuous coastal exposure occurs throughout the map area, with Facheux Bay and Northern Arm providing two excellent cross-sections. Exposure inland varies from 10%-80%.

The Facheux Bay area was mapped on a 1:250,000 scale by the Geological Survey of Canada (Williams, 1971) as part of the larger Burgeo map area. Parts of the area were briefly examined by Colman-Sadd (1974) as part of a Ph.D. thesis; he also mapped in detail part of the area to the east (Colman-Sadd *et al.*, 1979). Swinden (1980) closely examined the felsic volcanic rocks and associated sulfide occurrences in the Facheux Bay area. Mineral exploration has been carried out by the Newfoundland and Labrador Corporation (Dunlop, 1954) and by Falconbridge Nickel Mines Ltd. (1976).

GENERAL GEOLOGY

The Facheux Bay map area occupies that part of the Hermitage Flexure (Williams *et al.*, 1970) where northeasterly trending rocks of eastern Newfoundland "curve around" to form a generally east-west trending, sinuous configuration along the south coast. Structural and lithostratigraphic elements have a general east by north trend in the eastern part of the map area and a general west by north trend in the western part. Rock units within the area represent a continuation of the Baie d'Espoir Group (Jewell, 1939) as well as metasedimentary rocks, migmatites and granitoids of the Gander Zone (Williams *et al.*, 1974) to the east-northeast (Colman-Sadd, 1974; Swinden, 1980).

Rock units in the Facheux Bay area may be grouped into three broad subdivisions:

1) a central wedge of metasedimentary and metavolcanic rocks of the Bay d'Espoir Group,

2) a southern belt of synkinematic granitoids, and

3) a northern area of little-deformed two-mica granite.

Two formations of the Baie d'Espoir Group are recognizable in the area. The Isle Galet Formation (Colman-Sadd, 1974, 1976) consists largely of volcanic and pelitic rocks (Units 1-5); the Riches Island Formation (Colman-Sadd, 1974, 1976) is mostly semipelite and psammite (Unit 6). Other rocks here included in the Baie d'Espoir Group are metasedimentary rocks and minor migmatites (Units 7 and 8) which were previously designated as Little Passage Gneiss (Colman-Sadd, 1974; Swinden, 1980).

ISLE GALET FORMATION (Units 1 - 5)

The Isle Galet Formation consists of five stratigraphic units which can be traced from Lampidoes Passage in the

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east to Facheux Bay in the west. These units are disposed in a slightly overturned syncline in the north and a recumbent anticline in the south with both folds overturned to the south (see schematic cross-section on Figure 1). A regionally developed, north-dipping, phyllitic to finely schistose foliation is axial planar to these folds.

Unit 1 occupies the core of the anticline and consists of pelite and lesser felsic tuff. The gray to grayish black pelite is locally thinly laminated but its most pronounced feature is a strongly developed phyllitic foliation. Quartz stringers are common throughout and locally occur as discontinuous blebs outlining isoclinal fold hinges. The pelite is commonly garnetiferous, particularly in the Manuel Arm area, where the size and profusion of garnets decrease to the north.

Grayish white weathering, fine grained, felsic tuffaceous rocks are restricted in the Manuel Arm area to 15-25 m zones interlayered with the pelite. Locally, minor quartz and feldspar crystals, 1-2 mm across, occur in the tuff. A 150-200 m wide, fine grained, felsic tuff band with a pronounced sericitic foliation is bounded by pelite west of Facheux Bay. This band is continuous for most of the strike length of Unit 1 in that area and hosts nearly all of the sulfide showings in that region.

Unit 2 felsic volcanic rocks form four discrete belts in the map area. The two belts north of Unit 1 at and west of Manuel Arm represent a lower unit and an upper unit of felsic volcanic rocks, separated by a narrow band of mostly graphitic pelite and reworked tuff (Unit 3). The volcanic rocks in this area have been informally referred to as the Stanley Cove member by Swinden (1980). These, and their eastward extension to Lampidoes Passage, face north on the normal limb of the recumbent anticline. The two belts south of Unit 1 at and west of Manuel Arm are adjacent to each other and represent a northern belt of little-recrystallized felsic tuff which structurally overlies a belt of recrystallized felsic tuff; the latter contains profuse leucogranite veins. A possible fault, coinciding with the limit of leucogranite emplacement, defines the contact between the two. These belts of tuff and their extension on the north shore of Long Island are interpreted to be on the overturned limb of the recumbent anticline. The volcanic rocks at Long Island, however, do not have a leucogranite emplacement zone. Also, only minor leucogranite emplacement has occurred in the southern felsic volcanic belt west of Facheux Bay. All of these felsic volcanic rocks are here included in the Stanley Cove member of the Isle Galet Formation.

Plate 1. *Graded lapilli tuff faces up on the normal limbs of the anticline. Stanley Cove member (Unit 2) of the Isle Galet Formation at Stanley Cove.*

The Stanley Cove member consists mostly of strongly foliated, white to grayish white weathering, fine to coarse grained, felsic, crystal tuff. Conspicuous milky white and locally blue quartz

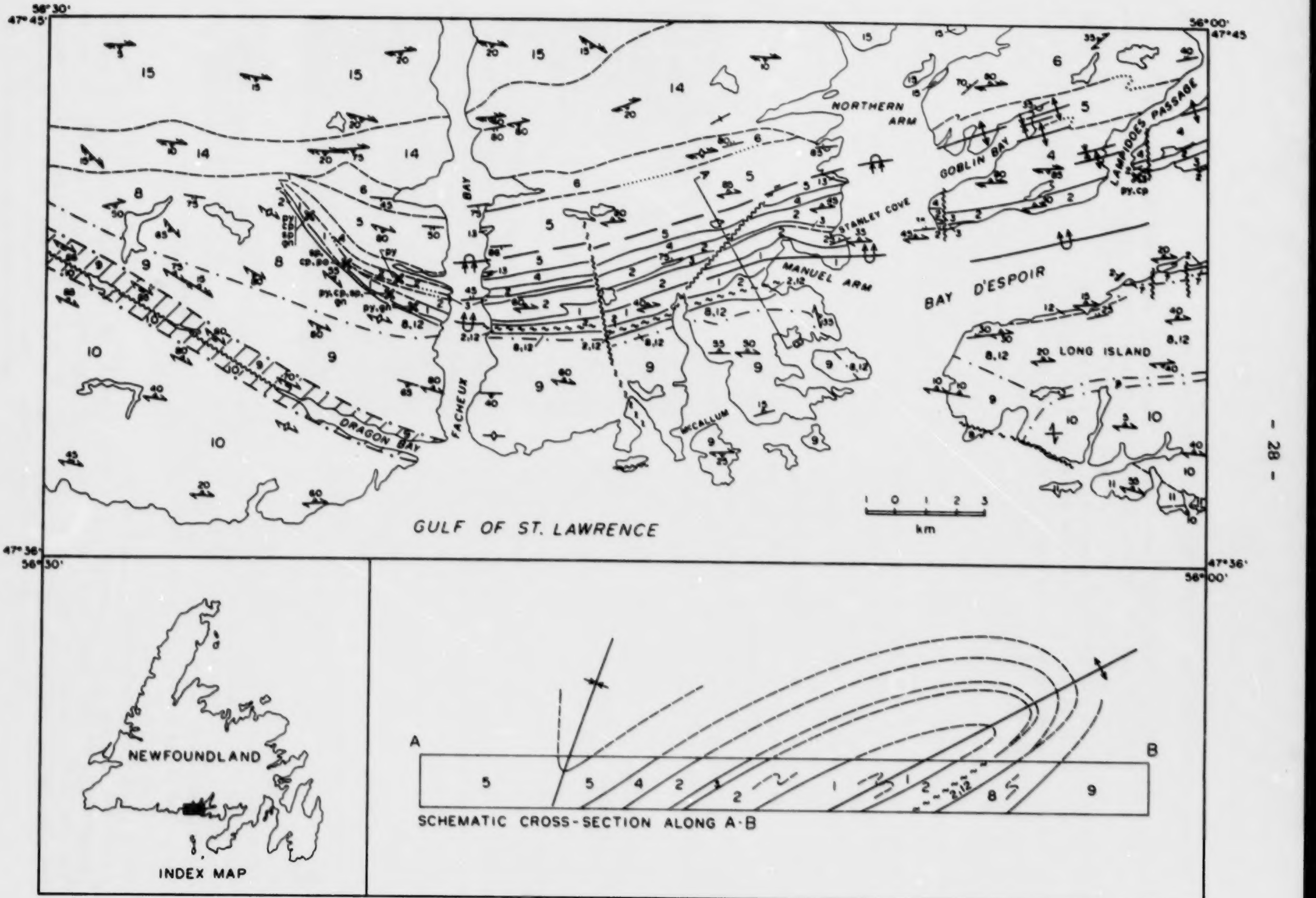


Figure 1. *Geological map of the Facheux Bay area, southern Newfoundland.*

LEGEND

DEVONIAN OR EARLIER

15 NORTH BAY GRANITE. Fine to coarse grained, equigranular to porphyritic, biotite greater than muscovite granite.

14 Intrusion breccia. Rafts of pelitic, semipelitic, and psammitic schist intruded by, or "floating" in, North Bay Granite.

13 Fine to coarse grained gabbro/amphibolite dikes, locally containing coarse grained hornblendite.

12 Fine to medium grained, muscovite greater than biotite, garnetiferous leucogranite.

11 PICCAIRE GRANITE. Medium to coarse grained, equigranular, biotite granite.

10 GAULTOIS GRANITE. Feldspar megacrystic, biotite rich, coarse grained granite; locally includes zones of equigranular granite.

9 McCallum granite (informal name). Fine to coarse grained, commonly layered, porphyritic, to equigranular, granite and granodiorite; locally includes leucogranite.

ORDOVICIAN OR EARLIER

BAIE D'ESPOIR GROUP (no stratigraphic order implied)

8 Recrystallized pelite, semipelite, psammite and amphibolite with profuse concordant leucogranite veins; locally becomes migmatitic.

7 Laminated pelite, semipelite, psammite, amphibolite and minor felsic tuffaceous bands with minor leucogranite.

6 RICHES ISLAND FORMATION. Laminated, semipelitic, staurolite schist and thickly bedded psammite; locally contains coticules.

ISLE GALET FORMATION (1-5)

5 Graphitic pelitic, lithic arenite, semipelite and banded, concordant amphibolite.

4 Mostly graphitic pelite with minor felsic tuff, amphibolite, and arenite.

3 Graphitic pelite, reworked felsic crystal tuff, muddy matrix conglomerate, and minor limestone.

2 Stanley Cove member (informal name). Fine to medium grained, quartz-feldspar crystal tuff, fine grained, laminated felsic tuff, massive rhyolite, minor conglomerate and minor mafic tuff (including amphibolite); southernmost band is recrystallized and contains profuse, concordant leucogranite veins.

1 Gray to black laminated pelite and fine grained, laminated felsic tuff.

SYMBOLS

Layering in granite (inclined, vertical)..

Recumbent F_1 fold (anticline, syncline)..

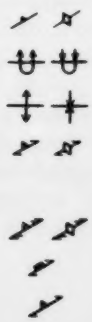
Upright F_2 fold (antiform, synform)..

Regional, penetrative foliation, S_1 (inclined, vertical)..............................

Weak cleavage in granite, crenulation cleavage to penetrative fabric in country rocks, S_2 (inclined, vertical)..

Mylonitic foliation (inclined)..

Migmatitic banding (inclined)..



crystals and feldspar crystals occur in a fine grained, light gray (on fresh surfaces), felsic matrix. Crystal concentrations vary from profuse in crudely graded beds of tuff (Plate 1), *e.g.* Stanley Cove, to sparse in fine grained, thinly laminated felsic tuff. As a generalization, the coarsest grained tuffs occur in the belt north of, and adjacent to, Unit 1. Locally porphyritic, steel gray rhyolite also occurs in this belt, particularly in the Manuel Arm area.

Narrow zones of graphitic pelite and laminated mafic tuff, in the order of 10 m wide, occur locally in the felsic tuffs. Some of these thin pelite bands form particular stratigraphic levels which persist from Northern Arm to Facheux Bay; this consistency of rock units is typical for that part of the map area.

In the southern, granite-intruded belt of felsic volcanic rocks, the tuffs are recrystallized, with fine grained biotite developed on the foliation planes. Locally, however, quartz and feldspar crystal clasts are preserved. The granite veins represent as much as 50% of the area outlined in this belt and consist of garnetiferous, leucocratic aplite and pegmatite. Although the contact with the adjacent belt of "granite-free" felsic tuffs is abrupt, small knots of aplite and pegmatite do occur locally, indicating the overall transitional nature of the zone. A penetrative foliation, locally with pronounced flattening and a flaggy-like parting, is common to both the granite veins and the volcanic rocks. Garnet and biotite are common in the "tuff plus granite" zone of the overturned limb but both also occur locally in the "granite-free" belt, *i.e.* north shore of Long Island.

Unit 3 effectively divides the Stanley Cove member into two stratigraphic horizons and, although less than 100 m thick, it can be traced from Lampidoes Passage to west of Facheux Bay. Along parts of its strike length, it consists entirely of black graphitic pelite. Commonly, however, muddy matrix conglomerate and reworked tuff occur. Clasts in the conglomerate range from 2-30 cm and consist of felsic tuff, rhyolite porphyry, and black pelite. The reworked tuff is a fine to coarse grained sandstone and consists of quartz (locally blue) and feldspar clasts in a fine grained black pelite matrix; isolated porphyry pebbles and pelite intraclasts locally "float" in the sandstone. Beds of laminated black pelite and coarser clastic material range from 0.5 to 4.5 cm in thickness and are locally graded. However, bedding is commonly chaotic, with lenses of crystal-rich material surrounded by the pelite. White weathering limestone, 1-3 m thick, occurs at the base of this northward facing unit, having been noted at Facheux Bay, Stanley Cove, Goblin Head and Copper Head. It commonly overlies a gray-white, cherty, pyritiferous horizon and is itself pyritiferous (Plate 2).

Plate 2. *White weathering limestone (marble) overlies gray chert. Base of Unit 3 of the Isle Galet Formation at Goblin Head.*

A phyllitic fabric is developed throughout most of Unit 3. Oriented biotite and hornblende occur in the matrix of Unit 3, east of the entrance to Lampidoes Passage.

Unit 4 consists mostly of graphitic pelite that conformably overlies the Stanley Cove member (Unit 2). The contact between the two is gradational over a few metres such that fine grained, thinly bedded tuff at the top of the member is interbedded with black pelite; tuffaceous beds also occur in the black pelite unit just above the contact. Unit 4 has greater areal extent east of Northern Arm due to refolding by open F_2 folds; minor arenite, felsic tuff and amphibolite are included in the unit in that region.

Unit 5 conformably overlies Unit 4. The fold axis of the slightly overturned syncline is sited in this unit such that rocks in the northern part of the sequence consistently face south. The unit consists of graphitic pelite, litharenite, semipelite and amphibolite which mostly occur in separate zones. However, the relative lack of inland exposure and the scale of mapping prevented a detailed subdivision of the unit.

Graphitic pelite commonly separates the other rock types in Unit 5. Dark gray to black, it contains a pronounced phyllitic foliation, axial planar to folded quartz stringers. Locally, feldspathic siltstone forms 3-5 cm interbeds in the pelite. The contacts between the pelite and other rocks types in the unit are conformable. The amphibolite is fine to coarse grained and commonly exhibits a regular 0.5-5 cm banding, defined by varying concentrations and grain size of amphibole. The amphibolite occurs as separate bands up to 20 m wide and may represent mafic tuff zones. The lithic arenite occurs in two bands, approximately 100-150 m wide, on either side of the syncline axis; bedding/cleavage intersections and grading in the Facheux Bay area suggest that they represent a single stratigraphic horizon repeated by the syncline. The fine to coarse grained arenite occurs in locally graded beds some 10-40 cm thick (Plate 3). Feldspar and clear to blue quartz form the matrix to pelite intraclasts. Fine grained biotite is developed on the penetrative foliation.

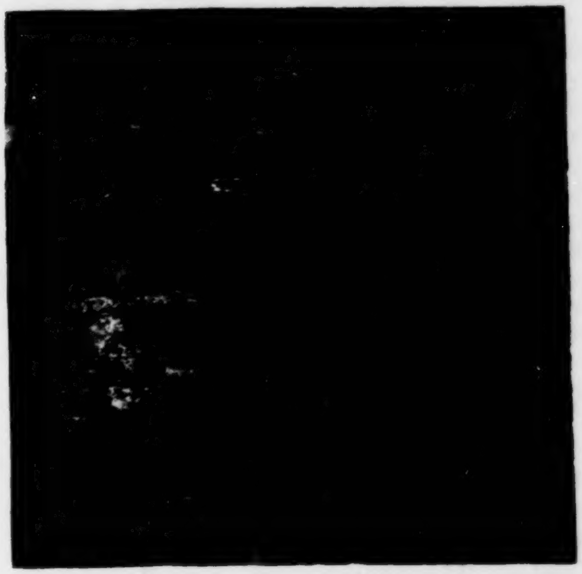


Plate 3. *Graded arenite is downward facing in cores of F_2 folds. Unit 5 of the Isle Galet Formation at Goblin Bay.*

RICHES ISLAND FORMATION (Unit 6)

The Riches Island Formation forms a single mappable unit along the northern boundary of the Isle Galet Formation. It appears to be older than Unit 5 along the contact and is almost certainly the time-stratigraphic equivalent of older units in the Isle Galet Formation. Lack of information on fold closures north of the syncline in Unit 5 and in Unit 6 prevent a more meaningful assessment of the stratigraphic relationships between the two formations.

Unit 6 consists of gray semipelite, psammite and minor arenite; the lack of amphibolite and the presence of only minor graphitic pelite are the strongest contrasts between it and Unit 5 of the Isle Galet Formation. The semipelite contains extremely uniform 1-10 mm laminations. These laminations are accentuated by late biotite and garnet porphyroblast growth, since Unit 6 is nearly everywhere in the aureole of the North Bay Granite (Unit 15). Regular garnet-quartz beds (coticules), 2-10 mm thick, occur with laminated semipelite north of Goblin Bay. Minor litharenite, locally graded and similar to that in Unit 5, is interbedded with the semipelite in the Facheux Bay area. The other prominent rock type in Unit 6 is fine grained, thickly bedded psammite; a clastic texture is not discernable in these 15-50 cm thick beds. Thin pelitic interbeds are common in the psammite.

UNITS 7 AND 8

Units 7 and 8 are included in the Baie d'Espoir Group and represent the higher metamorphic and granite-intruded equivalents of other rocks in the group. Unit 7 differs from Unit 8 in that only minor granite veining has occurred and the metamorphic grade is lower; both units appear to be on the overturned limb of the recumbent anticline along the north shore of Long Island.

Unit 7 consists of pelite, semipelite, psammite, amphibolite and minor felsic tuff. Most of these rocks weather dark green, dark gray or black and exhibit various degrees of recrystallization. The semipelite and psammite predominate and commonly form 4 to 20 cm beds containing 1-10 mm laminations. Black, graphitic pelite and banded, concordant amphibolite occur locally. Minor bands of felsic material, approximately 25 cm thick, form interlayers with black pelite adjacent to felsic tuffs of Unit 2. Some of the laminated semipelite/psammite beds preserve quartz and feldspar clasts 1-3 mm across; these are strongly reminiscent of laminated felsic tuff beds seen elsewhere in the Isle Galet Formation. Concordant knots and lenses of granite aplite and pegmatite, ranging from 2 to 5 cm in thickness, occur throughout Unit 7. Thicker, concordant granite veins are few. A pronounced, fine grained schistosity is subparallel to bedding and is defined by fine grained muscovite and biotite. A strong flattening component is obvious where the same fabric deforms the granite.

Unit 8 represents the continuation of Unit 7 on Long Island where there is a marked increase in the amount of concordant leucogranite veins; half or more of the outcrop area is garnetiferous leucogranite. The fine grained semipelitic and psammitic schist of Unit 7 is progressively and coarsely recrystallized towards the south such that medium to coarse grained muscovite/biotite schist occurs; banded amphibolite zones are common. Muscovite, biotite, and garnet commonly form porphyroblasts. Diffuse to sharp bounding planes are quite regular and separate pelitic to psammitic compositional varieties that are 4 to 20 cm thick. This layering is interpreted as primary as are 1-10 mm laminations that occur throughout. Along the north shore, the regional foliation dips more gently to the north than bedding, confirming the structural position of these rocks on the bottom limb of the overturned anticline.

Unit 8 is in contact with felsic volcanic rocks of the southernmost belt of Unit 2, west of Manuel Arm. The contact is abrupt but conformable; granite veins are common to both units.

Migmatite (Plate 4) is developed in Unit 8 and is generally spatially related to the McCallum granite (Unit 9). However, migmatite is more widespread in the western part of the area west of Facheux Bay. Quartz and granite sweats occur in the metasediments near the migmatite zones. These increase in volume such that concordant remnants of the pelitic to psammitic protolith "float" in a crudely banded granitoid host. The foliation in the granitoid is defined by discontinuous 0.5 to 1 mm concentrations of biotite that alternate with 2-5 mm granitoid zones. In this way, the granitoid is more of a gneissic granite than a granite gneiss.

Plate 4. *Migmatite. Unit 8 of the Baie d'Espoir Group at Facheux Bay.*

McCallum granite (Unit 9)

The McCallum granite is an informal name used here for an inhomogeneous granitoid zone that occurs throughout the south-central part of the map area. It was originally included in the Gaultois Granite (Colman-Sadd, 1974). However, the name Gaultois Granite is reserved for the more homogeneous megacrystic granite (Unit 10) that outcrops to the south.

Unit 9 comprises several phases of granitoid rocks. The most common is a medium to coarse grained, feldspar porphyritic, biotite rich, pink to pinkish-white weathering granite. The mostly potassic feldspar pheoncrysts are rectangular to square in section and range from 1 to 3 cm across. This type of granite forms a fairly homogeneous phase on the islands east of McCallum. Elsewhere it is commonly interlayered on a scale of 10 cm to 1 m with a similar, but less biotite-rich phase. Rarely, large feldspar crystals overprint the contact between two granite phases, indicating that some of the "phenocrysts" have a porphyroblastic component. Other layers are defined by variations in grain size and in the proportions of feldspar phenocrysts. Fine to medium grained, grayish-white weathering, granodiorite and dark gray diorite are also common phases. Contacts between these phases are abrupt but do not appear intrusive, *i.e.*, a regular plane marks the slight variation changes which can continue for several metres along strike as regular bands and, where observable, persist in cross-section (Plate 5). Locally the banding becomes wispy and "migmatitic looking" except that there is no metamorphic component; textures are completely igneous. Cross-cutting, garnet-tourmaline, granite aplite and pegmatite veins occur throughout.

The contact of the McCallum granite with Unit 8 is gradational over several metres and marked by partially assimilated xenoliths of metasedimentary rocks in the granite. The grain size of the granite is finer, and veins of biotite equigranular granite locally intrude, the metasedimentary rocks north of the contact. Both units are intruded in the contact area by a profusion of garnetiferous leucogranite aplite and pegmatite which generally persists into Unit 8. A moderate to strong foliation is developed throughout the McCallum granite. It is generally parallel to the different granite bands in plan but locally crosscuts the layering in cross-section. West of Dragon Bay the regional foliation becomes mylonitic within the Dragon Bay fault zone.

Plate 5. *Layering in the McCallum granite. Unit 9 at Facheux Bay.*

GAULTOIS GRANITE (Unit 10)

The Gaultois Granite (Colman-Sadd, 1974, 1980) outcrops on the southern side of Long Island as well as south and west of Dragon Bay. It consists of coarse grained, biotite-rich, feldspar megacrystic granite. Feldspar megacrysts are 1 to 6 cm long and rectangular to square; most are pink weathering potassic feldspars but a few plagioclase megacrysts do occur. Minor unseparated biotite equigranular granite is also included in Unit 10. The texture of the Gaultois Granite is generally dominated by a pervasive foliation which in some places has a cataclstic component; the megacrysts form augen in an oriented matrix of biotite and flattened quartz. Although mostly an "S" fabric, an "L-S" fabric was noted on the coast at Long Island. Mylonite zones a few metres wide occur locally, particularly on the coast west of Dragon Bay. The Gaultois Granite is also reduced to mylonite in the Dragon Bay fault zone, which separates the Gaultois from the McCallum granite west of Facheux Bay. Granite veins similar to equigranular phases in the McCallum granite intrude the Gaultois Granite on Long Island. However, interlayered porphyritic granite in the McCallum is similar, and probably related to, the Gaultois Granite. Garnetiferous leucogranite dikes intrude both granites in the contact area.

PICCAIRE GRANITE (Unit 11)

The Piccaire Granite (Colman-Sadd, 1980; Colman-Sadd *et al.*, 1979) intrudes the Gaultois Granite on the south shore of Long Island. It is a grayish-white weathering, medium to coarse grained, equigranular granite/granodiorite.

Minor feldspar phenocrysts occur locally. Biotite is common throughout and in some areas muscovite, possibly secondary, is developed. A weak foliation, defined by crudely oriented biotite, is developed in Unit 11 parallel to the regional trend. It does, however, grade into zones of intense flattening locally.

LEUCOGRANITE (Unit 12)

Unit 12 forms a gently northward dipping sheet of concordant leucogranite on the north shore of Long Island. It intrudes the metasedimentary rocks of Unit 8 and is representative of the many similar veins that occur throughout Unit 8 as well as the structurally lowest belt of Unit 2 felsic tuffs. The shallow dip combined with the parallelism of strike and shore line make this particular unit mappable on this scale.

The leucogranite is fine to medium grained and pink to white (more commonly white) weathering. Muscovite occurs throughout, both as oriented flakes and as disoriented "books", 2-5 mm across. Small red garnets are ubiquitous; tourmaline, other than in pegmatite patches, occurs rarely. A pronounced, penetrative foliation with associated quartz and feldspar augen is developed throughout; it locally weathers out as a flaggy-like parting.

GABBRO/AMPHIBOLITE (Unit 13)

Unit 13 mafic rocks form three small outcrop areas: two in Facheux Bay and one in Northern Arm. Lack of observable continuity inland has led to the interpretation that these rocks are intrusive. However, the possibility that they are recrystallized mafic tuffs is not ruled out.

The southern body in Facheux Bay has essentially a medium grained gabbroic texture. The northern one contains fine grained, banded amphibolite along its largely concordant contacts, but grades over 4-6 m into coarse grained, massive amphibolite. The centre of this body is marked by coarse grained hornblendite with 1-3 cm hornblende crystals. The body of Unit 13 in Northern Arm also varies from a fine grained amphibolite along its contacts to a medium grained, gabbro-like texture in its centre. All three are overprinted by the regional foliation.

NORTH BAY GRANITE (Units 14 and 15)

The North Bay Granite (Jewell, 1939) outcrops in the northern part of the map area. It is subdivided into two units: a contact zone of intrusion breccia (Unit 14) and the granite proper (Unit 15).

Unit 14 consists of North Bay Granite and metasedimentary country rocks of approximately equal proportions. The granite zones and metasedimentary rafts, up to 0.5 km wide, have a regional east-west strike. However, smaller disoriented xenoliths, several metres across, are spectacularly displayed in the cliffs of Facheux Bay and Northern Arm. The country rocks are mostly psammite, semipelite and pelite. All are recrystallized and biotite, garnet, and staurolite porphyroblasts are common. Locally, granite has so pervaded inclusions that an agmatite is produced. The granite zones consist of white to pale pink weathering, fine to medium grained, equigranular, biotite granite, locally containing minor muscovite and tourmaline. Offshoots from the larger granite zones cross-cut the regional foliation in the country rocks. The contact between Unit 14 and Baie d'Espoir Group rocks is relatively abrupt; a few garnetiferous leucogranite dikes occur within metres of the main intrusion breccia zone. However, a metamorphic aureole extends for a kilometre or more in the Bay d'Espoir Group, being most splendidly developed in the Riches Island Formation. Biotite, garnet and staurolite porphyroblasts (Plate 6) are common throughout this formation; most appear to overprint the main regional foliation.

Plate 6. *Staurolite porphyroblasts in semipelite within metamorphic aureole of North Bay Granite. Riches Island Formation (Unit 6) at Facheux Bay.*

Unit 15 represents an area that is fairly consistently underlain by granite; however, samll xenoliths are present locally. The granite is white to pale pink weathering, fine to coarse grained, and commonly porphyritic. Pink weathering feldspar phenocrysts, 1-3 cm long, occur sparsely east of Facheux Bay but the granite is markedly porphyritic west of the bay. Biotite is ubiquitous and minor muscovite occurs sporadically. Circular to elliptical clots of translucent quartz, 0.5 to 3 cm in diameter, were noted along Facheux Bay.

A weak to moderate biotite alignment occurs locally in the North Bay Granite, mostly along contacts in the intrusion breccia zone. For the most part, however, the granite is not penetratively foliated. An east-west trending, gently southward dipping, fracture cleavage is developed throughout Units 14 and 15. Discontinuous in any one outcrop, it is observable in most areas of granite exposure, particularly where weathering has accentuated the 0.5 to 1 cm spaced, "flaky" parting. For a more detailed report on the North Bay Granite, the reader is referred to Dickson and Tomlin (1983).

STRUCTURE AND METAMORPHISM

Distribution and facing directions of most rock units in the Baie d'Espoir Group are controlled by the large scale overturned syncline and anticline in the Isle Galet Formation (Fig. 2). The regional penetrative foliation has developed axial planar to these southward facing folds; the phyllitic to finely schistose fabric has gentle northward dips in the south and moderate to steep dips in the north. The change in dip reflects the progressive overturning from the syncline in the north to the anticline in the south. The foliation is consistently steeper than bedding on the normal or upper limb of the anticline and locally this combines with northward facing directions (Plate 1) to confirm the overall structure; vergence of small scale F_1 folds also indicates closure to the south. Fabrics are commonly parallel with primary elements on the overturned or bottom limb of the anticline. However, along the north shore of Long Island both bedding-cleavage intersections and vergence of small scale folds (Plate 7) indicate these rock are on the overturned limb. Rock units on the bottom limb are also attenuated such that felsic tuffs of Unit 2 form considerably thinner belts. Also, the graphitic pelite and reworked tuff of Unit 3 is missing, the probable site of some fault movement between the two tuff belts. Unit 4 pelite, as well, does not form a distinct mappable unit on the bottom limb; it may be caught up in the remobilized rocks of Unit 8 or may be locally faulted out.

The regional metamorphic grade appears to increase slightly from middle greenschist facies on the upper limb of

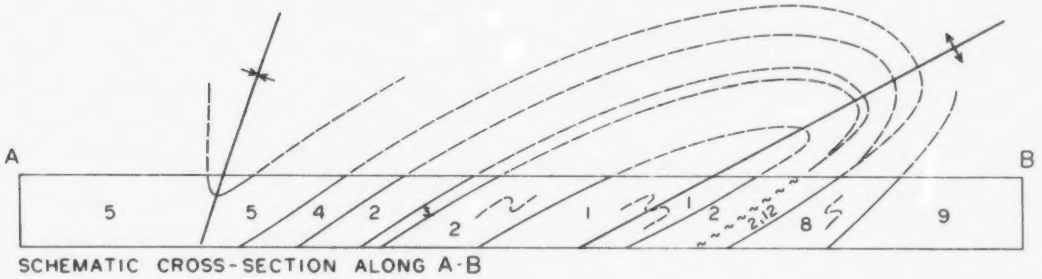


Figure 2. *Schematic cross-section along A-B. Section line is on Figure 1.*

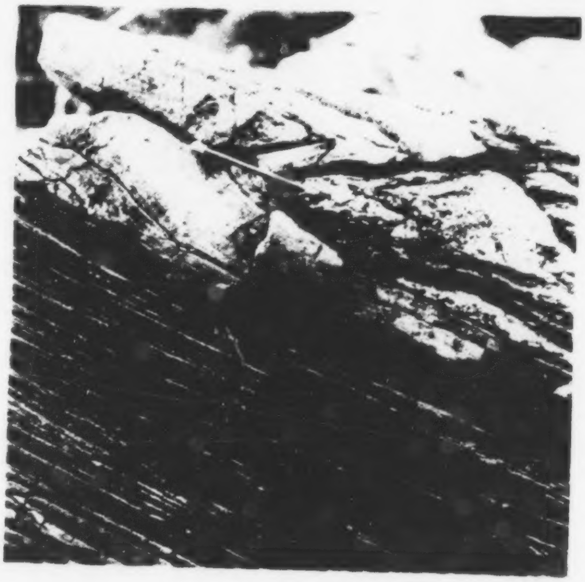


Plate 7. *Small scale F_1 "z" fold on the bottom limb of the large scale, overturned anticline. Unit 8 of the Baie d'Espoir Group, looking west along the north shore of Long Island.*

the anticline to upper greenschist-lower amphibolite facies on the lower limb. Garnets and oriented biotite occur in felsic volcanic rocks on the lower limb but were not observed on the upper limb, where sericite defines the foliation. Also, Unit 1 pelites in the core of the anticline at Manuel Arm are slightly more coarsely recrystallized, contain more and larger (2-4 mm) garnets, and a greater profusion of quartz sweats adjacent to the overturned limb. The increase in grade is also spatially related to leucogranite intrusion (Unit 12), which has pervaded to slightly different levels the structurally deeper rocks represented by the lower limb; these granite veins intrude the felsic volcanics at Manuel Arm but have not cut the same horizon on the north shore of Long Island. Northward, the overprinting effect of the North Bay Granite aureole camouflages the earlier regional metamorphism.

Felsic volcanics (Unit 2) of the Isle Galet Formation were previously separated from semipelite and psammite (Unit 7) on the north shore of Long Island by the Day Cove Thrust; rocks south of the thrust were interpreted as a possible basement complex called the Little Passage Gneiss (Colman-Sadd, 1974; Colman-Sadd *et al.*, 1979; Swinden, 1980). However, the structural pattern outlined above indicates that although the semipelitic and pelitic rocks of Unit 7 lie structurally below the felsic volcanics of Unit 2 they are actually stratigraphically younger than the volcanics. Also there are several indications of continuity across the zone including metamorphic grade, structural style and gradational rock types. Unit 7, of course, passes southward into the higher grade rocks of Unit 8, culminating locally in migmatite. Thus this zone is interpreted as a conformable sequence with metamorphism progressing structurally downward on the overturned limb. Also an analysis of the fold geometry shown in Figure 2 suggests that Unit 5, if folded around the nose of the anticline, would occupy a structural position equivalent to Unit 8; indeed, the highly metamorphic rock types in Unit 8 did have a protolith similar to Unit 5. Finally, although black graphitic pelite of Unit 4 is apparently missing along section AB at Manuel Arm, its structural position on the bottom limb at Long Island would be the contact area between Unit 7 and Unit 2. This area is the site of a topographic low as well as the previously assumed trace of the Day Cove Thrust; the single exposure found in this zone was black graphitic pelite.

The highest grade rocks of Unit 8 are spatially related to the McCallum granite (Unit 9) and the banding in the granite is mostly parallel to the regional foliation. This could suggest a synkinematic relationship between the granite and tectonism of the area. Leucogranite veins (Unit 12 and equivalents) are relatively later than the initial onset of deformation since, locally, xenoliths of McCallum granite show an internal foliation that has been rotated slightly in a leucogranite dike, which itself contains the same strong regional fabric as the McCallum granite (north of McCallum).

The regional foliation in the McCallum and Gaultois granites, west of Facheux Bay, culminates in a mylonite zone that extends northwestward from Dragon Bay and is informally referred to here as the Dragon Bay fault. The mylonite zone is approximately 1 km wide and the McCallum or Gaultois Granite protolith is recognizable on either side of a narrow central zone, 100-200 m wide, of ultramylonite. Every gradation from protomylonite to ultramylonite occurs within the zone; the latter locally has the appearance of a gray flinty chert.

A crenulation to strain-slip cleavage (S_2) is weakly to strongly developed throughout the area, superimposed upon the main foliation (S_1). It is preferentially developed in the pelitic rocks west of Northern Arm with little or no associated folding; it is mainly resolved as a widely spaced (1 to 4 mm), east-west trending, variably dipping fabric. It also forms a coarse fracture cleavage, overprinting the penetrative fabric of the regionally foliated granitoid rocks.

The S_2 cleavage is more penetrative east of Northern Arm such that it locally becomes a composite foliation with complete transposition of the earlier fabric. It is also steeply dipping in that area and axial planar to open, upright F_2 folds (Plate 8). The axial trace of these later, gently plunging folds is parallel or subparallel to the regional D_1 structures, but of considerably shorter wavelengths than the F_1 folds. Where superimposed upon the overturned limb of F_1 folds (Fig. 3), downward facing F_2 folds have developed (Goblin Bay). The distribution of lithological units is also influenced by the gentle F_2 folds in the Goblin Bay - Lampidoes Passage area, so that the moderately dipping, narrow belt of Unit 4 in the west becomes openly refolded in the east to produce the larger outcrop area.

Plate 8. *Small scale F_2 fold with steeply dipping, axial planar strain-slip cleavage. Unit 5 of the Isle Galet Formation at Goblin Bay.*

The North Bay Granite intruded after (or very late during) the first regional deformation of the Baie d'Espoir Group. Porphyroblasts in the aureole clearly overprint the main foliation. Locally, in the intrusion breccia zone, the "flaky" cleavage in the granite is equivalent to the strain-slip cleavage in the recrystallized metasedimentary rocks. Also, it would appear that the porphyroblasts in the granite aureole form augen within the strain-slip fabric planes. Thus the granite is interpreted as being post S_1 and pre to syn S_2; possibly the intrusion of the granite caused the shortening in the area that produced S_2.

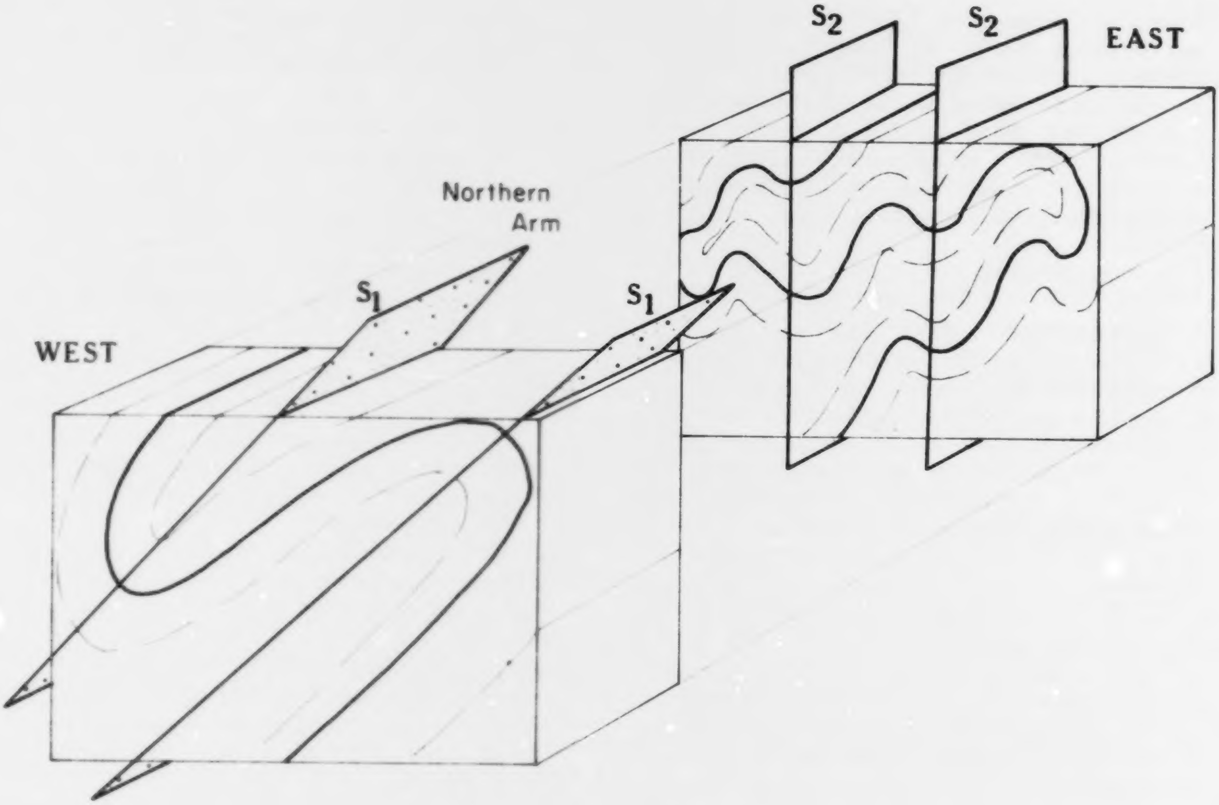


Figure 3. *A diagrammatic representation of the refolding of D_1 structures by F_2 folds east of Northern Arm.*

MINERALIZATION

All the known mineral showings in the map area occur in the Isle Galet Formation. The most important of these are a number of sulfide occurrences (Dunlop, 1954) in Unit 1, west of Facheux Bay. These are restricted to a 100-200 m wide band of fine grained, sericitized, felsic tuff within the largely pelitic unit; most contain pyrite with minor chalcopyrite, galena and sphalerite. The reader is referred to Swinden (1980) whose report on "Economic Geology of the Eastern Hermitage Flexure" deals specifically with mineralization in the Facheux Bay area, and to a more general discussion in a report by Colman-Sadd and Swinden (1981) on the "Geology and Mineral Potential of South-Central Newfoundland".

Pyrite was the onlv new mineral occurrence found in the map area. A pyrite showing occurs in Unit 2 felsic volcanics west of Facheux Bay. Massive, fine grained, white to dark gray weathering, rhyolite or chert contains a 25-30 cm wide zone rich in pyrite. The vocanics are fragmental in this zone with pyrite forming anastomosing stringers and pods around relatively pyrite free fragments of felsic material.

Pyrite occurs at or near the base of Unit 3 south of Goblin Bay. The thin limestone (marble) horizon (that locally marks the base) contains concordant pyrite lenses 1-4 mm wide parallel to lamellae in the carbonate. Disseminated pyrite also occurs throughout the carbonate and in an underlying white chert band. The same unit is displaced along a north-south fault at Lampidoes Passage where disseminated pyrite mineralization in the underlying white chert produces the Copper Head showing (See also, Swinden, 1980). Disseminated pyrite, of course, is ubiquitous in the graphitic pelite throughout the map area.

ACKNOWLEDGEMENTS

Morris West gave his usual first rate assistance during the field season. Both Morris and I wish to thank Jim and Elsie Fudge for being such friendly neighbours during our stay in McCallum. The manuscript was critically read by Stephen Colman-Sadd and Sean O'Brien for which they are sincerely thanked.

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NOTES ON THE METAMORPHIC ROCKS IN THE CORNER BROOK AREA (12A/13) AND REGIONAL CORRELATION OF THE FLEUR DE LYS BELT, WESTERN NEWFOUNDLAND

by

James Hibbard

INTRODUCTION

Geological reconnaissance was carried out in the Corner Brook map area (12A/13) during part of the 1982 field season. This work was intended to be the beginning of a two-year project involving regional correlation of the metaclastics, gneisses, and granitoids on the western side of Grand Lake with those of the Baie Verte Peninsula. Collectively, these rocks have been termed the Fleur de Lys Belt (Hibbard, in preparation). The crystalline rocks in the Grand Lake area were recently mapped by students and faculty at Memorial University (Knapp, 1980; Martineau, 1980; Kennedy, 1981; Williams *et al.*, 1982) and those of the Baie Verte Peninsula have been the subject of a Department of Mines and Energy project (Hibbard, in preparation). Although it is timely for a regional study of these rocks, it was found that the aims of the project could not be fulfilled because of the unexpected problems of (i) very poor exposure, (ii) very poor access, and (iii) lack of reliable 1:50,0000 scale mapping in the Corner Brook area. Hence, the project has been suspended. However, some interesting new observations were made on the Fleur de Lys Belt in the Corner Brook - Grand Lake area; they are described herein. In addition, a brief summary and comparison of rocks throughout the belt and recommendations for further work in the belt are presented.

GEOLOGY OF THE CORNER BROOK LAKE AREA

Kennedy (1981) divided the rocks southeast of the Trans Canada Highway into three units, including a westerly carbonate terrane, a dominantly metaclastic terrane, and an easterly cover of Carboniferous strata (Figure 1). He assigned the most easterly phyllitic rocks and recrystallized carbonates of the Lower Paleozoic carbonate terrane to the Grand Lake Brook Group and noted that they were overthrust by the metaclastic terrane. He informally subdivided the upper greenschist to lower amphibolite grade metaclastic terrane into the following three units: (i) Caribou Lake formation of mainly feldspathic psammites and metaconglomerate with subordinate greenschist and adamellite, (ii) Mount Musgrave formation of quartz semipelites, (iii) Twillick Brook formation of predominantly marble and pelitic schist. He assigned an Eocambrian to Cambrian age to these rocks based on lithic correlation with less deformed and metamorphosed rocks in western Newfoundland. Kennedy considered the metaclastic rocks to be in fault contact to the east with Carboniferous strata of the Anguille Group, although locally, at the very northeastern corner of the map area, he thought that the Anguille sandstone and shale unconformably overlapped the metaclastic rocks.

During the present study, the most significant observations centered upon a previously unrecognized sequence of rocks in the metaclastic terrane in the area of the Northern Harbour road (Figure 1), the status of some components of the Caribou Lake formation, and the nature of the faulted contact between the metaclastic terrane and the Grand Lake Brook Group.

Contribution to Canada-Newfoundland co-operative mineral program 1982-84. Project carried out by Newfoundland Department of Mines and Energy.

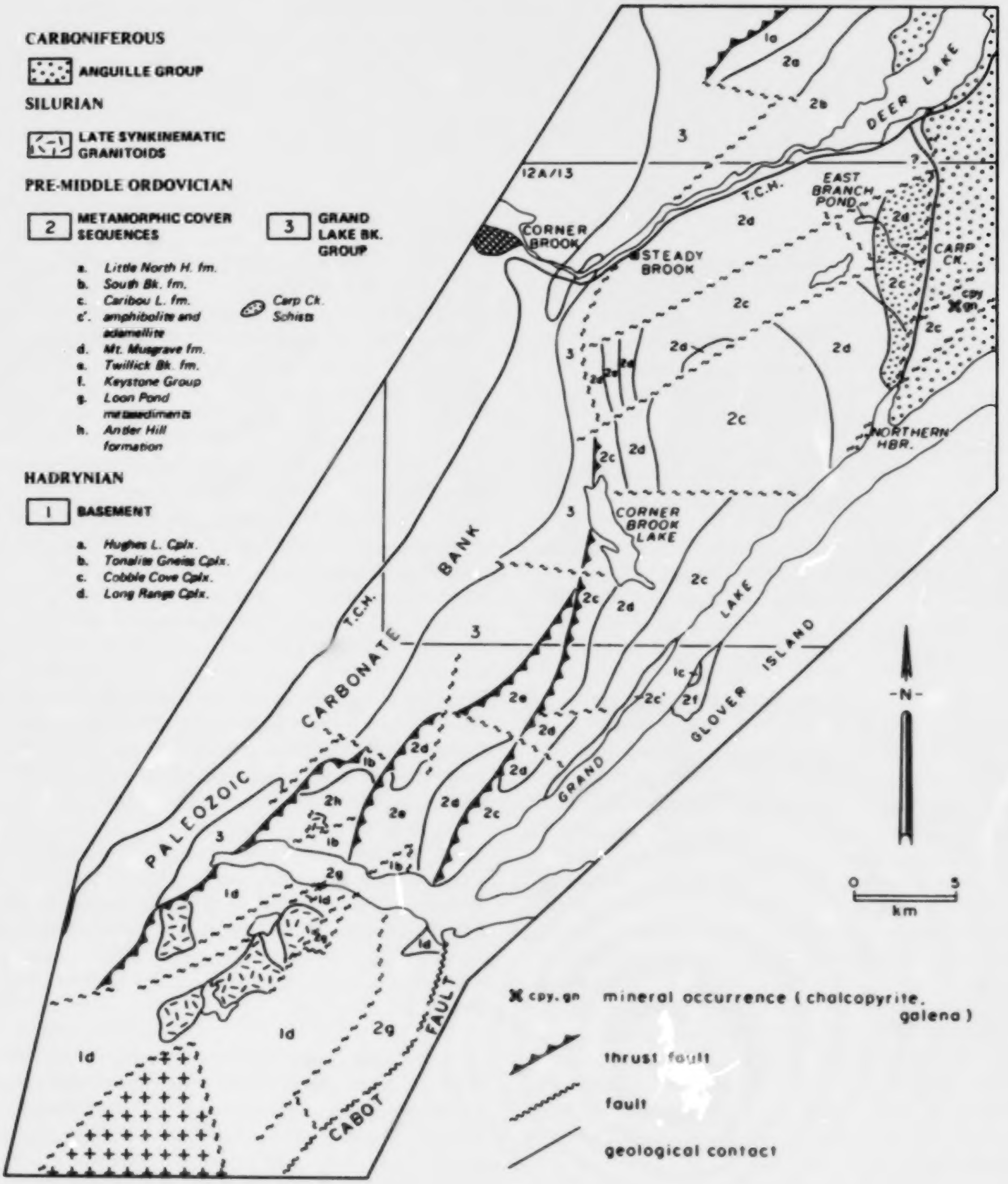

Figure 1. General geology of the area west of Grand Lake, Newfoundland. The order of the metamorphic cover sequences listed above is geographic and not intended to be stratigraphic.

Rocks immediately to the west of the Northern Harbour road were originally assigned to the Caribou Lake and Mount Musgrave formations (Kennedy, 1981). However, mapping during this study indicates that a sequence of metaclastic schists and amphibolite, distinct from either formation as described by Kennedy, strikes approximately parallel to the road, dips moderately to steeply eastward, and extends approximately 2 km inland, to the west of the road. The best exposed section of these rocks is on Carp Creek and, hence, are informally referred to here as the Carp Creek schists. The schists strike across previously erected stratigraphic boundaries (Kennedy, 1981). The full extent of these rocks is uncertain, although their known distribution is outlined on Figure 1 by the stippled area. The Carp Creek schists are dominated by gray, quartz-muscovite semipelite that is commonly garnetiferous and forms layers up to 10 cm thick. They are similar to schists of the Mount Musgrave formation; however, in contrast, they include substantial amounts of graphitic schist in layers up to 5 m thick as well as greenschist and amphibolite. The mafic rocks are best exposed on Carp Creek, where more than 100 m of plagioclase-porphyroblastic amphibolite is interlayered with the metaclastic rocks. The Carp Creek schists appear to grade structurally downward into coarser, more feldspathic semipelite and psammite that, in the area of East Branch Pond, are magnetite-rich. The stratigraphic significance of the Carp Creek schists is uncertain; however, their presence indicates that more detailed mapping of all of this northerly part of the Corner Brook area is required for a more accurate portrayal of the stratigraphy of the metaclastic terrane.

Greenschist, amphibolite, and granite east of the Northern Harbour road and immediately northeast of Northern Harbour were previously assigned to the Caribou Lake formation (Kennedy, 1981). Similar rocks outcrop southwards along strike on the western shore of Grand Lake and are spatially related to the Caribou Lake formation. In the Northern Harbour area, it appears that numerous granitic dikes and stocks intrude the mafic schists, locally crosscutting a penetrative fabric in them; however, the granite was involved in a later, intense deformation that affected all of the rocks. Since the granite appears to be unrelated to the mafic schists, it is suggested that it be excluded from the Caribou Lake formation. However, the granite is unseparable from the amphibolite at a scale of 1:50,000, hence future work on these rocks may indicate that the whole of this mafic schist-granite terrane be assigned the status of a complex. A new chalcopyrite-galena occurrence was found in the amphibolite and it appears to be spatially related to the granite (Figure 1). Chalcopyrite is disseminated through the amphibolite near the contact with the granite and also forms veins that crosscut fabric in the mafic rocks. The galena forms disseminated blebs up to 5 mm across in the amphibolite.

The faulted contact between the metaclastic terrane and the Grand Lake Brook Group was interpreted to be a thrust zone, termed the Corner Brook Lake thrust (Kennedy, 1981). Kennedy noted that the fault, which is moderately east-dipping in the Corner Brook area, steepens to the north and is a high angle fault at Steady Brook. Williams *et al.* (1982) have noted that a fault between phyllites similar to those of the Grand Lake Brook Group and gneissic basement of the metaclastic terrane north of Deer Lake (north of the 12A/13 area), is moderately overturned to the east. During the present study, this faulted contact between the carbonate and metaclastic terranes was investigated in the Corner Brook Lake area, at Steady Brook and in the area just north of Deer Lake; these exposures indicate that this contact is marked by at least three different faults rather than a single thrust zone overturned to the north.

The fault zone is poorly exposed in the Corner Brook Lake area, although where seen it is a highly disturbed, moderately east-dipping zone of friable pelitic schist. Numerous boulders containing coarse garnet- (up to 3 cm diameter), kyanite-bearing (up to 5 cm long), muscovite-quartz schist occur in the valley defining the trace of the fault just north of the lake. Although this rock type was not observed in outcrop, a highly altered and flattened muscovite schist with large patches of chlorite forming pseudomorphs of garnet is exposed in the fault zone approximately 2 km north of the lake. The spatial association of the boulders with the fault zone and the similarity between the rock type in the boulders and those deformed rocks in the fault zone suggest that the garnet-kyanite schist is associated with the Corner Brook Lake thrust in this area. This rock is particularly noteworthy in that it is the first report of kyanite from this metamorphic terrane. Its sole occurrence near such a significant tectonic break as the Corner Brook Lake thrust further supports a link between this spectacular rock and the thrust.

North of Corner Brook Lake, at Steady Brook, the contact between the Mount Musgrave formation and the Grand Lake Brook Group is a nearly vertical to steeply west-dipping fault zone. This fault zone is marked solely by contorted and highly deformed rocks of each unit juxtaposed along a narrow, fissile phyllitic zone. Polydeformed rocks of the Mount Musgrave formation that lie immediately to the east of the fault display a very intense late foliation and garnet in these rocks is largely altered to chlorite.

On the logging road leading to Old Man Pond, north of the Corner Brook map area, the basement gneisses of the metamorphic terrane structurally underlie phyllites and carbonates of the carbonate bank along a northwesterly dipping fault (Williams *et al.*, 1982). This fault zone is marked by approximately 20 m of rubbly mylonitic schists. These schists locally contain large (>2 cm) alkali feldspar porphyroblasts and, in places, these porphyroblasts have coalesced along with quartz to form postkinematic migmatitic pockets of coarse granite up to 1 m by 0.5 m in size. Unoriented biotite porphyroblasts are common in the fault schists in particular near the migmatitic zones.

It is apparent from the nature of these faulted contacts between the metaclastic and carbonate terranes that either different structural levels of the Corner Brook Lake thrust are exposed along its trace or different generations of faults are responsible for the juxtaposition of the terranes in different areas. Since rocks on each side of the fault appear to maintain consistent metamorphic grade along the strike of the contact, I prefer to view the zone as polygenetic. One other note of interest concerning this faulted contact is that structures on either side of the zone have previously been correlated (Kennedy, 1981). In view of the profound juxtaposition of rock types along this poorly exposed, complex zone, any correlation of structures across it is considered to be suspect (see Regional Correlation).

REGIONAL CORRELATION

At the start of this study, the regional geology of the Fleur de Lys Belt in the Grand Lake area was compiled from the work of Knapp (1980), Martineau (1980), Kennedy (1981) and Williams *et al.* (1982). The stratigraphy of the belt in the Grand Lake area is presented and compared with that of the Baie Verte Peninsula in Table I. This chart, along with my own observations, provide the basis for the following discussion on regional correlation both within the Fleur de Lys Belt in the Grand Lake area and throughout the belt.

The stratigraphy of the belt in the Grand Lake area is similar to that of the Fleur de Lys Belt elsewhere. It consists of three major components, including a gneissic basement, a polydeformed and polymetamorphosed cover sequence, and late phase granitoids. The basement, where exposed throughout the region, appears to be represented by mainly tonalitic gneisses, although granitic gneisses and anorthosite occur in the southern part of the area (Martineau, 1980). All of these rocks are considered to be Grenvillian in age (Knapp *et al.*, 1979; Williams *et al.*, 1982). It is interesting to note that, at the southern end of Grand Lake, calc-silicate schists are closely associated with the basement rocks; however, the interrelationship of these units is uncertain (Martineau, 1980; Kennedy, 1981). The calc-silicate schists may be equivalent to felsic metavolcanic rocks recently found in the Hughes Lake Complex (Table I) to the north (H. Williams, personal communication, 1982) and all of these may represent the basal part of the cover sequence.

The cover sequence is a somewhat homogeneous assemblage of metaclastic rocks with locally prominent units of marble, amphibolite, and greenschist. Its relationship to the basement is uncertain, but it is thought to range from Eocambrian to Lower Ordovician in age based on lithologic correlation with less deformed rocks of western Newfoundland (Martineau, 1980; Knapp, 1980; Kennedy, 1981; Williams *et al.*, 1982). Based on regional correlation, Kennedy (1981) has inferred a shorter time span for rocks on the western side of Grand Lake (Table I). However, his correlation may be too restrictive, considering the dearth of fossils in the less deformed rocks he compares with the metaclastic cover. In the Grand Lake area, the general cover sequence is interpreted to consist of basal units of quartzofeldspathic psammite and metaconglomerate with local intercalations of amphibolite. These are overlain by more pelitic schist and capped, at least in the western Grand Lake area, by marble (Kennedy, 1981). Where separated, the basal metaclastic units include the Antler Hill, Caribou Lake, and Little North Pond formations; stratigraphically higher, the more pelitic and marble-bearing units include the Mount Musgrave, Twillick Brook, and South Brook formations. At Glover Island, pelitic rocks and marble of the Keystone Group, appear to form the lower portion of the sequence (Knapp *et al.*, 1979) and thus, appear to be atypical of the stratigraphy.

The late synkinematic granitoids are confined to the southerly part of the Grand Lake area (Martineau, 1980; Kennedy, 1981). These include adamellite, granite, and syenite. A dike, assumed to originate with the Last Hill adamellite (Table I) has yielded a K/Ar biotite age of 420 ± 20 Ma (Kennedy, 1981). The more southerly granitoids, the Tulks Pond, Goose Hill and Hare Hill plutons, locally contain hastingsite (Martineau, 1980). Based on the age date and the presence of hastingsite, these plutons have been correlated with the locally peralkaline Topsails batholith in west-central Newfoundland (Kennedy, 1981).

Comparison of Fleur de Lys Belt rocks at Grand Lake with those on the Baie Verte Peninsula indicates that there are differences between respective basement terranes and late phase granitoids. The cover sequences in the two areas are grossly similar, but there are second order differences between the metaclastic cover sequences.

Basement gneisses on the Baie Verte Peninsula are represented by small patches of migmatitic gneiss and banded gneiss in the East Pond Metamorphic Suite and by screens of granitic gneiss included in the basal amphibolite unit of the White Bay Group (Table I). The granitic gneiss is identical to gneisses in the Grenville basement on the western side of White Bay and appears to be similar to gneisses in the southerly part of the Grand Lake area. The migmatites and banded gneisses of the East Pond Metamorphic Suite are different

TABLE I: SUMMARY OF STRATIGRAPHY OF THE FLEUR DE LYS BELT

	S. of Grand Lake (Martineau (1980)	Glover Island Knapp (1980)	W. of Grand Lake Kennedy (1981)	N. of Deer Lake Williams et al. (1982)	Baie Verte Peninsula Hibbard (1983)
POST- L. ORDOVICIAN	Tulks Hill, Goose Hill, Hare Hill Granites		Last Hill Adamellite		Wild Cove Pond Igneous Suite and Partridge Pt. Granite
LOWER ORDOVICIAN	? Loon Pond Metasediments	? Keystone Schist Group			Fleur de Lys Supergroup ? ?
CAMBRIAN			Twillick Brook Fm. Mt. Musgrave Fm.	Pasadena Group South Brook Fm.	White Bay Group Rattling Brook Group ? Birchy Complex
HADRYNIAN			Antler Hill Fm. Caribou Lake Fm.	Little North Pond Fm.	Old House Cove Group
HELIKIAN & OLDER(?)	Long Range Complex	Cobble Cove Complex	Tonalite Gneiss Complex	Hughes Lake Complex	Granitic Gneiss East Pond Metamorphic Suite

from all other basement rocks in the Fleur de Lys Belt. It has been suggested that these rocks could represent a structural basement of highly deformed and migmatized Paleozoic cover rocks (Hibbard, in preparation). In addition to the gneissic basement, it is possible that some of the northeastern part of the belt in the Baie Verte area may have an ophiolitic basement represented by parts of the Birchy Complex. Although greenschists similar to those of the Birchy Complex occur in the Keystone Group on Glover Island, there is no evidence either for its intercalation with the metaclastic terrane or for its having an ophiolitic affinity.

The cover sequence is grossly similar throughout the Fleur de Lys Belt. On the Baie Verte Peninsula, it consists of a coarse, feldspathic basal unit (Old House Cove Group) which laterally interfingers with and is overlain by more pelitic units (White Bay and Rattling Brook Groups). There appear to be more amphibolite pods and layers in the basal clastic sequence of the Baie Verte area than in that of the Grand Lake area. Locally on the Baie Verte Peninsula, as in the Grand Lake area, the more pelitic units directly overlie the basement gneisses. The White Bay Group overlies granitic gneiss at the southern end of White Bay; similar relationships occur between the Keystone schists and basement on Glover Island. The White Bay Group is also compositionally very similar to the Keystone schists, although the Keystone schists are a thinner sequence than the White Bay Group. Both units have a basal amphibolite that is overlain by pelitic schists, pebbly metaconglomerates containing granite and quartz clasts, and marbles. It is noteworthy that marble occurs stratigraphically low in these sequences. Kennedy (1981) interpreted the marble sequence (Twillick Brook formation) on the western side of Grand Lake to be the stratigraphic top of the cover sequence, based solely on lithologic correlations with less deformed rocks of western Newfoundland. Considering the stratigraphic position of other marble units in the Fleur de Lys Belt and the lack of any compelling biostratigraphic evidence, it is possible that the Twillick Brook formation could encompass a much greater time range. It is conceivable that the formation may in part, be laterally equivalent to stratigraphically lower marble-bearing units in other parts of the belt such as the Keystone schists and the White Bay Group. The major difference between the metaclastic cover rocks at Grand Lake and Baie Verte is the greater proportion of graphitic schist and amphibolite and mafic schist in the more pelitic units of the Baie Verte area. This may reflect a more distal, basinal depositional environment for the Baie Verte rocks.

The late phase granitoid rocks along the belt appear to be of different age and origin; these differences appear to reflect significant differences in the tectonic setting of different parts of the Fleur de Lys Belt. On the Baie Verte Peninsula, the Wild Cove Pond Igneous Suite has yielded a K/Ar biotite age of 358 Ma (Hibbard, in preparation), which is much younger than the approximately 420 Ma age for the granitoids in the Grand Lake area. Geochemically, the Wild Cove Pond Igneous Suite is calc-alkaline and shows no tendency towards peralkalinity, as seen in the Grand Lake granitoids. Also, the granitoids at Grand Lake have been involved in late phase regional deformation, whereas the Wild Cove Pond Igneous Suite postdates any regional deformation.

The change in late phase granitoids from north to south coincides with a change in the tectonic character of the Fleur de Lys Belt. In the northern part of the belt, rocks are in generally upright, horizontal to slightly plunging major folds and juxtaposed against more westerly rock units along a major steep fault, the Cabot Fault (Figure 2). In contrast, in the Grand Lake area, the belt is characterized by moderately east-dipping thrust faults and largely appears to have been thrust westwards

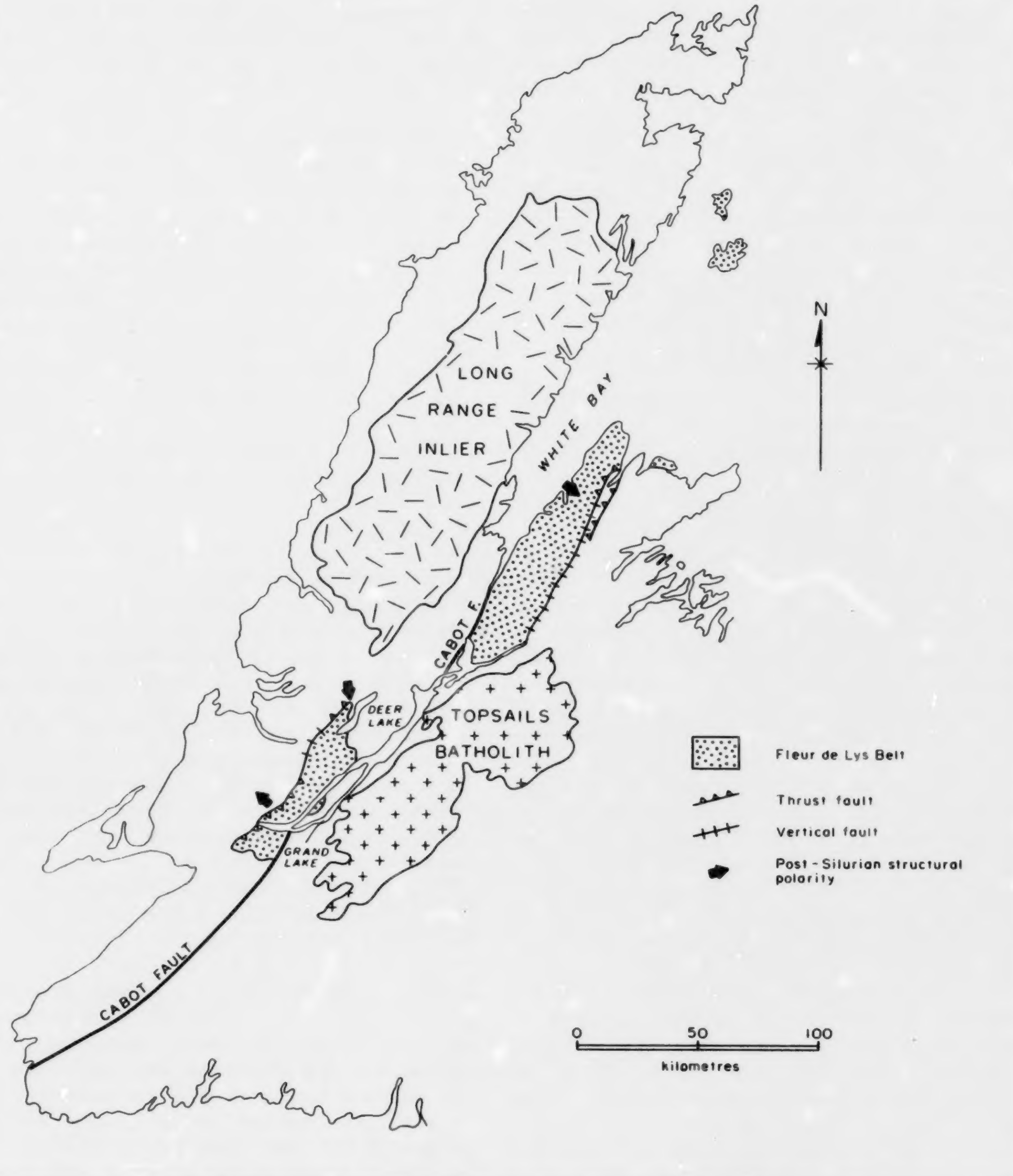

Figure 2. Tectonic setting of the Fleur de Lys Belt in Newfoundland.

over the western Newfoundland carbonate bank sequence. Based on observations noted above, I suggest that, during the Silurian, the part of the Fleur de Lys Belt now in the Grand Lake area occupied the area now underlain by the Topsails batholith (Figure 2); with the intrusion and uplift of the batholith at about 420 Ma, the metamorphic terrane was thrust westwards, partially decapitating the Topsails Granite and thus accounting for the inclusion of late phase granitoids in the Grand Lake area. This hypothetical scenario suggests an Acadian time of deformation for the Grand Lake Brook Group, situated structurally below the metaclastic thrust sheets, and accounts for the westward decrease in metamorphic grade and intensity of deformation in the carbonate terrane. It implies that Lower Ordovician volcanic rocks situated between the Topsails batholith and the Fleur de Lys Belt were also transported during the post-Silurian event. A major uncertainty in this reasoning is the amount and type of displacement along the Cabot Fault in the Grand Lake area, so a palinspastic reconstruction across this prominent zone can only be only tentative.

On the Baie Verte Peninsula, post-Silurian tectonic movement had an opposite, easterly polarity from that of the Grand Lake region. This polarity may have been induced by uplift of the Grenvillian Long Range Inlier (Figure 2). The change in polarity from west-directed to east-directed movements along the Fleur de Lys Belt appears to be located between Corner Brook Lake and the area just north of Deer Lake; this zone may mark the range of structural influence of the Long Range Inlier during post-Silurian times. It is curious, and may be critical to understanding of the tectonics of the area, that Topsails-like magmatism is absent in the belt on the Baie Verte Peninsula but is present in the southern end of the belt. Clearly, the orthotectonic Fleur de Lys Belt deserves closer scrutiny with respect to its role in post-Silurian tectonics in Newfoundland.

RECOMMENDATIONS FOR FUTURE WORK

The following recommendations are made for the type of approach to any further work in the area:

i) Comprehensive 1:50,000 scale mapping of the Fleur de Lys Belt in the Corner Brook map area (12A/13);

ii) Mapping of the Loon Pond metasedimentary rocks at the southern end of Grand Lake for better stratigraphic resolution;

iii) $^{40}Ar/^{39}Ar$ age dating of muscovite from phyllites of the Grand Lake Brook Group to test the hypothesis that the group was involved in post-Silurian tectonism;

iv) Better assessment of the stratigraphic position of the marble in the Grand Lake area (possibly by paleontological methods) and its potential for copper mineralization;

v) Radiometric age dating of the basement terrane.

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GEOLOGY OF THE D'ESPOIR BROOK MAP AREA AND PART OF THE FACHEUX BAY MAP AREA, SOUTH-CENTRAL NEWFOUNDLAND[1]

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Abstract

The D'Espoir Brook map area, in south-central Newfoundland, is dominated by the Silurian North Bay Granite which has intruded a variety of gneissic, metasedimentary and foliated granitoid rocks which range in age from possibly Late Precambrian to Ordovician. Possible Precambrian basement rocks consist of strongly foliated tonalitic and granodioritic biotite ± muscovite gneiss and migmatite which form large screens (up to 2 km^2) within the granitoid terrane. Middle Ordovician metasedimentary rocks of the Baie d'Espoir Group outcrop along the northern and southern margins of the map area and consist of polydeformed and highly metamorphosed biotite-garnet psammites and semi-pelites with minor staurolite-bearing schist. Near the northern margin of the map area, an elongate belt of strongly deformed granitoids has intruded the Baie d'Espoir Group. The North Bay Granite, which has been radiometrically dated at 430 and 427 Ma, cuts all the other major units in the area. The North Bay Granite consists of four major rock types: medium grained, equigranular, biotite ± muscovite granodiorite; medium grained, porphyritic, biotite granite; medium grained, equigranular, biotite ± muscovite granite; and coarse grained, coarsely porphyritic, biotite granite. All units of the North Bay Granite have been variably deformed during the later deformation events of the metasediments. The deformation of the metasediments and North Bay Granite is considered to be Acadian. The North Bay Granite has been intruded by a few massive diabase and microsyenite dykes. No significant metallic mineral occurrences were found. Four large quartz veins (one of which has been assessed at over 1.22 x 10^{6}t) have some potential as a source of silica.

Introduction

Location and Access

The D'Espoir Brook map area is located in south-central Newfoundland between 47°45'N and 48°N and longitudes 56°W and 56°30'W. Facheux Bay map area (11P/9) is located immediately to the south (Fig. 39.1). The town of St. Albans is located about 10 km east of D'Espoir Brook map area. Access to the northeast corner of the map area is gained by the Upper Salmon River hydro-electric project access road.

North Bay, East Bay and Facheux Bay provide access to Facheux Bay map area and the southern part of D'Espoir Brook map area. These fjords, however, are bounded by high, steep cliffs which prevent access to the plateau. Most of the study area was mapped from the helicopter-placed fly camps and by canoe and foot traverses from the road.

Exposure is excellent in the southern and eastern parts of the map area, and along the ridge to the west of D'Espoir Lake. In the remaining areas exposure is poor and much of this area was surveyed by helicopter.

Previous Work

Jewell (1939) mapped the North Bay and East Bay area as part of a survey of the Bay d'Espoir area and introduced the term North Bay Granite. The only other major work carried out in the map area was by Williams (1971) who mapped at 1:250 000 scale and defined the main lithological units. Colman-Sadd (1974, 1980) and Colman-Sadd and Swinden (1981) have briefly described a few aspects of the geology in the North Bay and Facheux Bay areas and postulated that a Late Precambrian gneissic basement is present, mainly as large screens, within the North Bay Granite.

Butler (1973) and Butler and Greene (1976) carried out a detailed geochemical assessment of a large quartz vein near the northern edge of the map area to determine the potential of the vein as a source of silica.

The D'Espoir Brook and Facheux Bay map areas formed part of a reconnaissance lake sediment geochemical survey carried out by Butler and Davenport (1978), Davenport and Butler (1981) and Davenport (1982) to assess the mineral potential of south-central Newfoundland. Only tungsten gave a significant anomaly within D'Espoir Brook map area (Davenport, 1982).

The adjacent map area to the east (1M/13) was mapped by Colman-Sadd (1976). The area to the south (11P/9) was mapped by Blackwood (1983) and part of the map area to the north (12A/1E) was mapped by Colman-Sadd (1983). The map area to the west (11P/15) will be mapped during 1983.

General Geology

The rocks of the D'Espoir Brook map area can be divided into four main units as follows:

Strongly deformed paragneiss, tonalitic gneiss and migmatitic granite and granodiorite which occur as large screens and underlie sizeable areas within the North Bay Granite. These gneisses are concentrated in the east-central and eastern parts of the map area and along the northern margin of the North Bay Granite. Colman-Sadd (1974) has termed some of these deformed rocks the Little Passage Gneisses. The structural complexity of the gneisses compared to the Baie D'Espoir Group led Colman-Sadd (1974, 1976) to suggest that the gneisses were possibly Precambrian.

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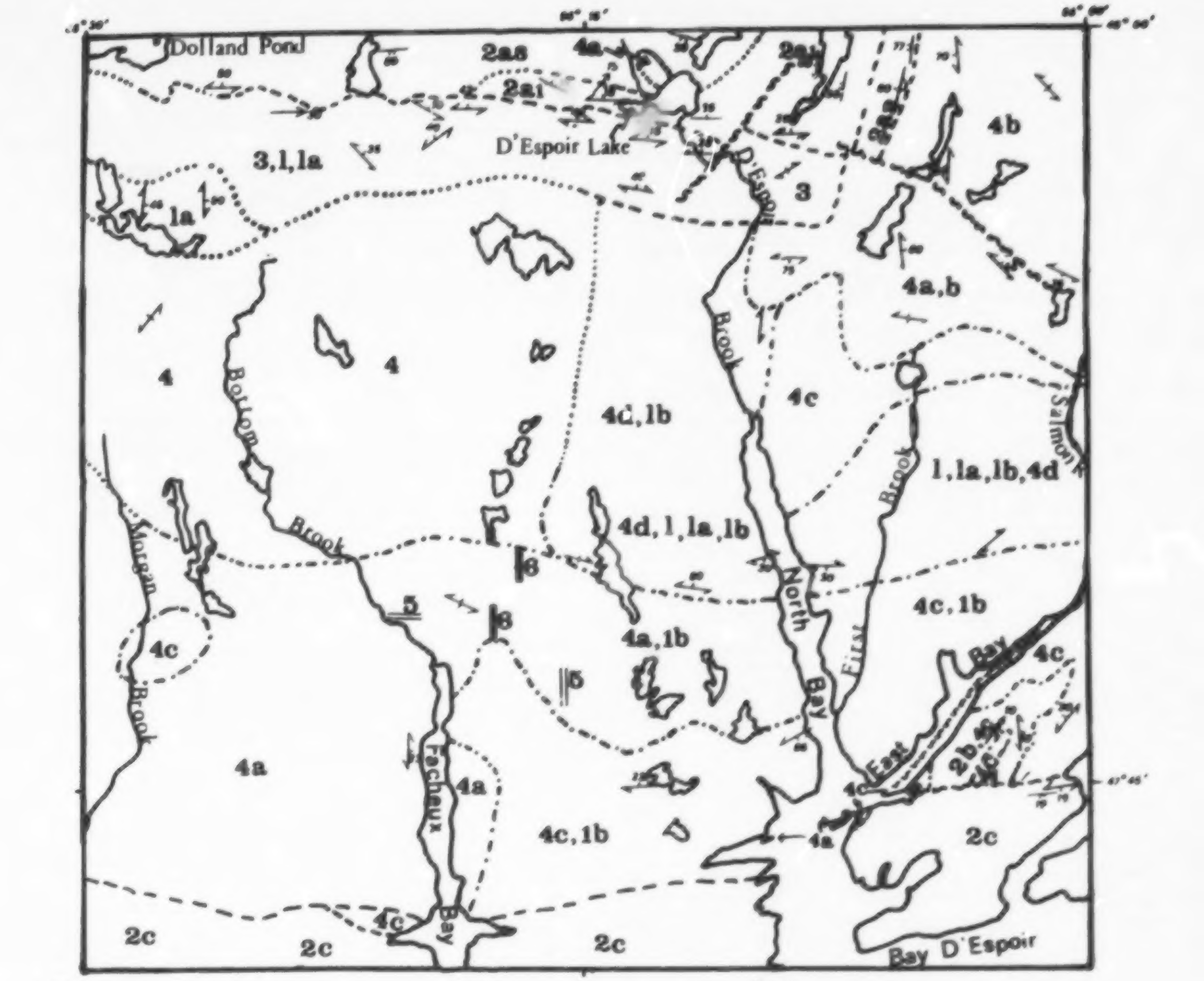

Figure 39.1. Geology of D'Espoir Brook map area (11/P1 and part of Facheux Bay (11/P9), Southern Newfoundland.

Variably deformed and metamorphosed metasediments of the Salmon River Dam Formation and the Riches Island Formation which form part of the Ordovician Baie d'Espoir Group.

Strongly deformed granitic gneiss, foliated granite and leucogranite which are located along the northern margin of the North Bay Granite.

The North Bay Granite consisting of a variety of granitoids that range in composition from biotite granodiorite to garnet-muscovite leucogranite. The granitoids also vary in degree of deformation from locally strongly schistose granitoids in the northeast of the map area to weakly deformed or massive in the remainder of the map area.

Rb-Sr (whole rock) age dates from the eastern end of the North Bay Granite (east of the map area) have been determined by Elias (1981) who obtained Rb-Sr (whole rock) ages of 430 ± 4 Ma and 427 ± 11 Ma. These dates indicate a Silurian age for the North Bay Granite.

LEGEND FOR FIGURE 39.1

CARBONIFEROUS ?

6 Massive, fine grained, diabase dykes.

DEVONIAN ?

5 Massive, fine grained, leucocratic biotite-hornblende microsyenite dykes.

SILURIAN

4 North Bay Granite:

4a, Massive, medium grained, porphyritic biotite granite;

4b, medium to coarse grained, porphyritic biotite granite;

4c, medium grained, equigranular to slightly porphyritic biotite ± muscovite granodiorite;

4d, massive, medium grained, equigranular biotite ± muscovite granite.

3 Strongly foliated, equigranular to porphyritic biotite-muscovite and biotite granite, and garnet-muscovite leucogranite.

ORDOVICIAN

2 Baie d'Espoir Group:

2a, Salmon River Dam Formation;

2a1, Thin to medium bedded, grey sandstones, calcareous sandstones; minor limestone;

2a2, thin bedded black, rusty pelites and semi-pelites;

2a3, strongly deformed and metamorphosed equivalent of 2a1-upper greenschist facies;

2b, Riches Island Formation: Interbedded pelites, semi-pelites and psammites. Variably metamorphosed from lower greenschist to upper amphibolite facies;

2c, Undivided Baie d'Espoir Group: Includes metasediments, metavolcanics, migmatites, and minor granitic dykes from the North Bay Granite.

PRECAMBRIAN ?

1 Strongly foliated orthogneiss and paragneiss.

1a, banded, pink, medium grained, biotite granodioritic migmatite;

1b, strongly schistose, semi-pelites, psammites, amphibolites, orthoquartzites.

The area has been substantially modified by glacial action. The central part of the map area is covered by a thick blanket of till, which contains well rounded boulders up to 3 m in diameter. Ultramafic boulders were found throughout the map area and indicate a minimum transportation of 40 km from the nearest known source of ultramafics. Several southerly trending eskers occur in northern part of the map area; the largest is 5 km in length. Glacial striae and stoss and lee surfaces indicate a southerly direction of ice movement.

Description of units

Precambrian?, strongly foliated, orthogneiss and paragneiss - Unit 1

A variety of strongly deformed and metamorphosed granitoid and metasedimentary rocks occur throughout the North Bay Granite in the study area. Two main areas of these rocks can be defined. One area, to the south and west of D'Espoir Lake within unit 3, contains strongly banded, biotite granodiorite gneiss which occurs as abundant large xenoliths in the strongly foliated granitoids. The other area is located south of D'Espoir Lake, within units 3 and 4, and consists of several square kilometres of granodioritic gneiss which is cut by numerous thin pegmatite dykes and massive granodiorite dykes (subunit 4c). On the east side of North Bay, the gneiss is tonalitic and locally garnetiferous and has a well developed vertical L-S fabric. No metasedimentary xenoliths were found in the orthogneiss.

Subunit 1a consists of a pink, medium grained, biotite granodiorite with an abundance of slightly contorted, well-aligned, discontinuous layers of biotite, up to 6 cm long and 1 to 3 mm thick. The granodiorite matrix has a weak foliation which is parallel to the aligned biotite layers. The rock is possibly an injection gneiss or migmatite. This rock type is best exposed on the west side of North Bay and near the northwest corner of D'Espoir Brook map area.

Subunit 1b is tentatively included within unit 1. The rock types include strongly schistose amphibolite facies semi-pelites, psammites, amphibolites, and orthoquatzites, which are locally migmatized. Biotite psammite, the most common rock type within subunit 1b, occurs as screens which range in length from a few centimetres to about 100 m. Sillimanite-bearing, biotite-rich semi-pelite also forms a few screens. The southern portion of the North Bay Granite, mainly within subunit 4c, contains an abundance of metasedimentary screens. Throughout the map area, the screens contain a strong tectonic foliation which is commonly folded. The main deformation of the screens clearly predates their incorporation into the North Bay Granite. In areas where the granite contains a tectonic fabric, this fabric can also be traced into the sedimentary screens at an angle to the main fabric in the metasediments.

Colman-Sadd (1974, 1976, 1980) has included the metasediments, which are spatially associated with the orthogneisses (unit 1), within a Precambrian basement terrane. However, the strong similarity in grade of metamorphism, degree and style of deformation, and lithology of these metasediments with those of the Riches Island Formation to the south indicates that the paragneiss may be Ordovician rather than Precambrian in age (see Blackwood, 1983).

Ordovician Baie d'Espoir Group - Unit 2

This unit was not examined in detail within map area 11P/9 in this project. Blackwood (1983) mapped this unit in 11P/9 and has described it as pelitic, semi-pelitic and psammitic schists, with concordant, leucogranite veins and migmatites, which are probably Ordovician in age. The unit is cut by the North Bay Granite in map area 11P/9.

Ordovician Salmon River Dam Formation - Unit 2a. The Salmon River Dam Formation (unit 2a), within the map area, is located along the northern margin of the North Bay Granite and unit 3 and forms the lower part of the Baie d'Espoir Group (Colman-Sadd, 1976). In the lesser deformed areas of the formation (subunit 2a1), the rocks consist of thin to medium and parallel bedded, grey sandstones and calcareous sandstones, with poorly developed parallel laminations, graded beds, local flame structures and convolute laminations. Most beds are massive. One isolated thick, massive bed of limestone also occurs at the southern edge of the subunit, close to the contact with unit 3, southwest of D'Espoir Lake. Subunit 2a2, conformably overlies subunit 2a1 and consists of thinly bedded, and strongly cleaved, rusty siltstones and sandstones with locally well developed parallel laminations. Subunit 2a3 is probably a higher grade metamorphic equivalent of subunit 2a1. It is also more intensely deformed with tight isoclinal folds, transposed bedding, and commonly contains two strong schistosities. Subunit 2a3 also contains minor metatuff. Granitoid veins and dykes are common within subunit 2a3, and these are also strongly deformed.

The Salmon River Dam Formation, within the map area, can be divided into two structural units. To the west of D'Espoir Lake, the Salmon River Dam Formation bedding and cleavage generally have a strong easterly trend. S_1 is generally parallel to S_0, and near the contact with unit 3 bedding dips gently to the north at about 15° A second step cleavage, axial planar to open folds, trends towards the northeast. To the east of D'Espoir Lake, the metasediments have a northerly trend with a steep S_1 cleavage parallel to S_0. S_2 transposes S_1 and has an easterly trend. Lack of exposure has obscured the intermediate area but from an aerial photo interpretation there appears to be a gradual change in structural orientation which indicates the presence of a major gently plunging northerly trending synform.

West of D'Espoir Lake, within subunit 2a1, a tight isoclinal fold occurs within a thinly bedded unit. The axial plane is subparallel to bedding and the fold axis plunges gently to the northeast. This is probably an F_1 fold and indicates that subunit 2a1 has been recumbently folded.

Ordovician Riches Island Formation - Subunit 2b. To the southeast of East Bay (within map area 11P/16), a sequence of interbedded pelites, semi-pelites, and orthoquartzites (subunit 2b), which have been polydeformed and invaded by thick granite dykes (subunit 4c), is tentatively assigned to the Ordovician Riches Island Formation of Colman-Sadd (1976). The sequence is dominated by highly metamorphosed biotite-muscovite schists which locally contain garnet and staurolite. Interbedded with the schists is a sequence of strongly cleaved orthoquartzites which is concentrated in a northeasterly trending belt in the centre of the area.

To the south of the easterly trending fault near the southeast corner of map area 11P/16, the Riches Island Formation consists of thin to medium bedded, black pelites which structurally underlie a thick sequence of psammites found mainly within map area 11P/9.

The Riches Island Formation is polydeformed with two main tectonic fabrics and two readily apparent fold generations. S_1 is a gently dipping schistosity, which is subparallel to bedding and is also axial planar to F_1 folds. The fold axes of the F_1 folds plunge to the northeast at a low angle. The S_1 schistosity is folded by F_2 and forms upright to slightly overturned folds with a moderate to steeply dipping axial planar cleavage. The F_2 folds also plunge to the northeast at a low angle.

Granite and pegmatite dykes are abundant throughout the Riches Island Formation and have been deformed during the second deformation of the metasediments.

Undivided foliated granites and granodiorites - Unit 3

Unit 3 consists of a variety of strongly foliated, mair leucocratic granites which range in composition and textu from medium grained, equigranular, biotite granite a porphyritic biotite granite to equigranular muscovite-garn granite and pegmatite.

Southeast of Dolland Pond, medium grained, biotit muscovite granite intrudes metasediments of the Ordovici Salmon River Dam Formation. Southeast of D'Espoir Lak the leucogranite contains small xenoliths of grey psammi which are clearly derived from the Salmon River Da Formation to the north. The contact is otherwise unexpos and is generally marked by a pronounced break in slope fro the granite to the metasediments. Tonalitic gneiss (unit commonly occurs as screens in unit 3, particularly south D'Espoir Lake and 6 km east-southeast of Dolland Por Unit 3 is cut by weakly foliated biotite granodiorite dyk similar to subunits 4c and 4d.

The generally poor exposure of unit 3 and the presen of a great variety of granites has prevented a meaningf subdivision of the various varieties of foliated granite.

The granites of unit 3 are strongly deformed, with well developed foliation defined by aligned mica a flattened quartz and feldspar. Locally, a second fabric folding of the first fabric may be found. The first fab generally dips gently to the north. In the vicinity of D'Esp Lake, the granites are more intensely deformed than t adjacent metasediments. It is possible that t metasediments and the granites in the D'Espoir Lake area a in fault contact.

North Bay Granite - Unit 4

The North Bay Granite has been subdivided into fo subunits (4a-4d) based on rock type and texture. Contac are generally gradational and only subunit 4c has a cle intrusive relationship with the other subunits. Dykes subunit 4c have intruded subunits 4a and 4b. The contac between the other units are considered to be gradational grain size, colour, proportion of muscovite and the proporti of phenocrysts may vary over distances of about 1 k Granitoid dykes from the other units are generally absent.

The undivided area of the North Bay Granite (unit 4 Fig. 39.1) is an area of very poor exposure with a number varieties of granite. The widely scattered outcrops prevent meaningful subdivision of this area.

Massive, medium grained, porphyritic, biotite granit Subunit 4a. Subunit 4a is mainly located in the souther southwestern and eastern parts of the map area. T dominant rock type is pink to white, porphyritic biot granite with 10 to 20% phenocrysts of alkali feldspar to 2 cm in length, in an equigranular matrix of quar plagioclase, alkali feldspar and biotite and rare muscovite. the southwest corner of the map area, the granite contains prominent but weak fabric defined by poorly aligned biot and phenocrysts of alkali feldspar.

Immediately to the north of First Brook, subunit contains a relatively high proportion of garne (approximately 1%), which range in diameter from less th 1 mm to over 1 cm. The large garnets are highly shatter and are slightly altered. Inclusions of quartz are commo present in the large garnets. The granite also contains mir muscovite. Screens of schist are also locally abundant in th area.

Dykes of grey, equigranular, biotite granodiori similar to subunit 4c, cut subunit 4a. These are particula prominent along North Bay. However, the contacts betwe th main bodies of subunits 4a and 4c are apparen gradational over 1 km.

Small pegmatite dykes, which locally contain muscovite, are common throughout subunit 4a. Two microsyenite dykes (unit 5) and two diabase dykes (unit 6) also cut subunit 4a.

Medium- to coarse-grained, porphyritic, biotite granite - Subunit 4b. Subunit 4b is located in the northeast corner of the map area and mainly consists of coarse grained, highly porphyritic, biotite granite which generally contains a weak foliation and/or alignment of potassium feldspar phenocrysts. The unit is cut by a southeast trending fault along which the granite is strongly foliated.

Contacts with the metasediments to the west are not exposed and granite dykes were not found to cut the country rock metasediments. However, screens of strongly schistose biotite psammite and semi-pelite, with minor limestone occur along the fault trace within the granite and these are cut by granite dykes. The contact with subunit 4c is difficult to define. Dykes of subunit 4c cut subunit 4b but no sharp contact was found between the subunits. Towards the southern limit of subunit 4b, in the northeast corner of the map area, the granite becomes finer grained and the size of the phenocrysts is smaller. However, the change is so gradual that in this area subunit 4a is probably equivalent to subunit 4b. Along Salmon River, subunit 4b also occurs as screens in subunit 4c.

The granite consists of essential quartz, microcline, plagioclase and biotite. Muscovite is rarely present. In subunit 4b, phenocrysts range in length from 2 cm to over 10 cm, with an average of 6 cm.

The fabric in the weakly foliated granite is generally defined by the orientation of phenocrysts and a weak parallel alignment of biotite and slightly flattened quartz. The strongly deformed granite along the fault has a mylonitic fabric which dips to the northeast at about 60°. This fabric decreases in intensity to the south over 2 km.

Medium grained, equigranular to slightly porphyritic, biotite ± muscovite granodiorite - Subunit 4c. Subunit 4c is mainly located in the southeastern half of the map area. The dominant rock type is grey, massive to weakly foliated, medium grained, equigranular, biotite granodiorite which locally contains up to 1% muscovite. Screens of migmatite, schist, and granitic gneiss are common, particularly near the entrance to North Bay and East Bay. Some screens are over 100 m in length and, on the cliffs at North Bay, large screens are completely surrounded by granodiorite. Williams (1971) has described this area of abundant screens as a zone of intrusion breccia.

Fine grained, biotite granodiorite dykes and thin pegmatite dykes are common throughout the subunit. Well developed, parallel, alternating biotite-rich and biotite-poor layers, 2 to 3 mm wide, occur in a few outcrops of generally massive granodiorite and are possibly a result of flow foliation.

The granodiorite contains a weakly developed, steeply dipping, easterly trending, tectonic fabric which is defined by poorly aligned biotite.

Minor beryl mineralization occurs in a thin granite pegmatite vein north of East Bay. Pegmatite and quartz veins are particularly abundant south of East Bay, in the vicinity of the contact with the Riches Island Formation.

Massive, medium grained, equigranular, biotite ± muscovite granite - Subunit 4d. This unit is predominately a buff, massive, medium grained, equigranular, biotite granite, which locally contains less than 1% muscovite. The granite locally contains a weak tectonic fabric defined by aligned mica.

West of North Bay, the central part of the unit contains a large proportion of foliated granite, gneiss and migmatite screens. Pegmatite dykes and locally garnetiferous granite veins occur throughout the unit. Quartz veins and segregations are common in the screens but are rare within the granite.

Microsyenite dykes - Unit 5

Massive, fine grained, leucocratic, biotite-hornblende microsyenite dykes were found north and east of Facheux Bay and cut subunit 4a of the North Bay Granite. North of Facheux Bay, the microsyenite forms thin anastomosing veins which cut pegmatites and aplites. Northeast of Facheux Bay, a 10 m wide, northerly trending dyke underlies a prominent northerly trending lineament. This dyke can be traced for over 300 m. These dykes may be related to the Devonian Cape La Hune "Granite" which is described as a syenite by Williams (1971).

Diabase dykes - Unit 6

Two diabase dykes cut subunit 4a of the North Bay Granite, northeast of Facheux Bay. The dykes are 15 cm and 30 cm to 1 m wide respectively. The dykes trend about 180° and are fresh, massive and fine grained, with well developed, chilled margins. Similar dykes occur throughout the Gander Zone and have been considered to be Carboniferous in age (Jayasinghe and Berger, 1976).

Mineralization

Trace amounts of pyrite were found at scattered localities in the North Bay Granite. At one locality, west of Facheux Bay tourmaline associated with the pyrite, occurs along a joint surface. However, an examination of the area failed to reveal further mineralization.

Pyrite-rich pelites occur within the Riches Island Formation in fault contact with the granite. Two generations of pyrite can be determined. Highly flattened pyrite occurs along cleavage planes and euhedral pyrite forms veins on joint surfaces in the pelites. The pelites possibly have some potential for copper mineralization.

A small outcrop of highly silicified, rusty gossan occurs close to the contact between the Salmon River Dam Formation and the unit 3 granitoids (Williams, 1971). Apart from pyrite, no metallic mineralization was found, although Williams (1971) speculated on the possibility of molybdenite mineralization.

Large quartz veins occur along the contact between unit 3 and the Salmon River Dam Formation and cut both units. The largest vein is 12 km west of D'Espoir Lake and cuts the metasediments. Another vein cuts strongly foliated granite 10 km west of D'Espoir Lake, close to the contact with the metasediments. Two smaller veins are located close to the contact between unit 3 and the Salmon River Dam Formation, south of D'Espoir Lake. The largest vein is 600 m in length and up to 100 m in width; the smallest of the major veins is aout 50 m wide and 100 m in length.

Butler (1973) and Butler and Greene (1976) have described and geochemically sampled and largest vein, 12 km east of D'Espoir Lake, and assessed a silica content of 1.22×10^6t. The average analysis of the vein is 97.1% SiO_2, 1.9% Al_2O_3 and 0.5% Fe_2O_3.

The two veins south of D'Espoir Lake are similar to the largest quartz vein west of D'Espoir Lake and probably have a similar chemistry but the vein 10 km west of D'Espoir Lake contains abundant screens of granite and, therefore, has little potential as a source of silica.

Davenport (1982) reported anomalous tungsten values in lake sediment samples taken from the northeast corner of the map area and also southeast of East Bay. A careful examination of the granitoids in these areas did not uncover any wolframite mineralization or alteration. The anomaly in the northwest corner of the map area is within an area of migmatitic granodiorite gneiss (subunit 1a), close to the contact with units 3 and 4. The East Bay anomaly lies within an area of high grade metasediments, biotite-muscovite granite and garnet-tourmaline pegmatite which are cut by numeorus small quartz veins.

Geochemistry

Samples of granitoid rocks were collected from 260 sites using a 2 km grid system from the North Bay Granite in map areas 11P/15, 11P/9 and 12A/1. These samples will be analyzed for major elements and about 20 trace elements including Sn, W, F, Mo, Li and U and will be reported in the final report of this project.

Summary and Conclusions

The Ordovician metasedimentary rocks of the Baie d'Espoir Group have reached the amphibolite facies of metamorphism and have a complex structural history which mainly predates the North Bay Granite. Small recumbent folds and gently dipping cleavage and schistosity indicate that the major folds in these units are also recumbent and verge to the southeast. The gently dipping schistostiy in the strongly foliated granites of unit 3 may also be related to the recumbent folds or possibly to thrusting.

The gneissic granitoids (unit 1) may be older than the Ordovician metasediments and could be basement rocks. Most of the high grade paragneisses are probably Ordovician. However, the situation is still not clear. Samples of the gneissic granitoids have been collected for age dating and may clarify the relationships.

The North Bay Granite is a composite body with a wide variety of granitoids. The granite was syntectonically intruded into the Baie d'Espoir Group, as both contain similarly oriented cleavages. Screens of metasediment are abundant in the granite along a 1 to 2 km wide belt along the southern contact. The latest fabric in the screens is also found in the granite.

A few minor pyrite occurrences occur within the North Bay Granite. However, no other metallic mineralization or any significant alteration of the granite was found. Sizeable quartz veins in the north of the map area have some potential as a source of silica.

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GEOLOGY OF THE EASTERN HALF OF THE PETER SNOUT MAP AREA (11P/13E), NEWFOUNDLAND

by

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INTRODUCTION

The Peter Snout (11P/13) map area is situated in southwestern Newfoundland. It contains elements of the Gander and Dunnage zones of the Appalachian orogen and it is underlain by lower to mid-Paleozoic rocks of the Hermitage Flexure belt.

Previous geological studies in the eastern half of 11P/13 include the 1:250,000 scale mapping of Riley (1959), the unpublished work of Buchans Mining Company, Hudson's Bay Oil and Gas, Shell Minerals and Falconbridge Nickel Mines Ltd., and the reconnaissance mapping and compilation of Smyth (1979). That part of the map area that lies to the west of Grandy's Brook was also mapped by Chorlton (1980a).

The area was extensively glaciated during the late Wisconsinian and evidence of this glaciation is ubiquitous. The Grandy's River valley is the most prominent glacial feature in the area. Elsewhere, the morphology of the region east of the valley is dominated by drumlins, ramps, sand ridges and *roches moutonées*.

The eastern half of the Peter Snout map area is traversed by part of a 160 km all weather, unpaved road (Route 480), which joins the community of Burgeo to the Trans Canada Highway (Route 1). Although the road provides access to much of the map area, aircraft support is needed in the more remote parts.

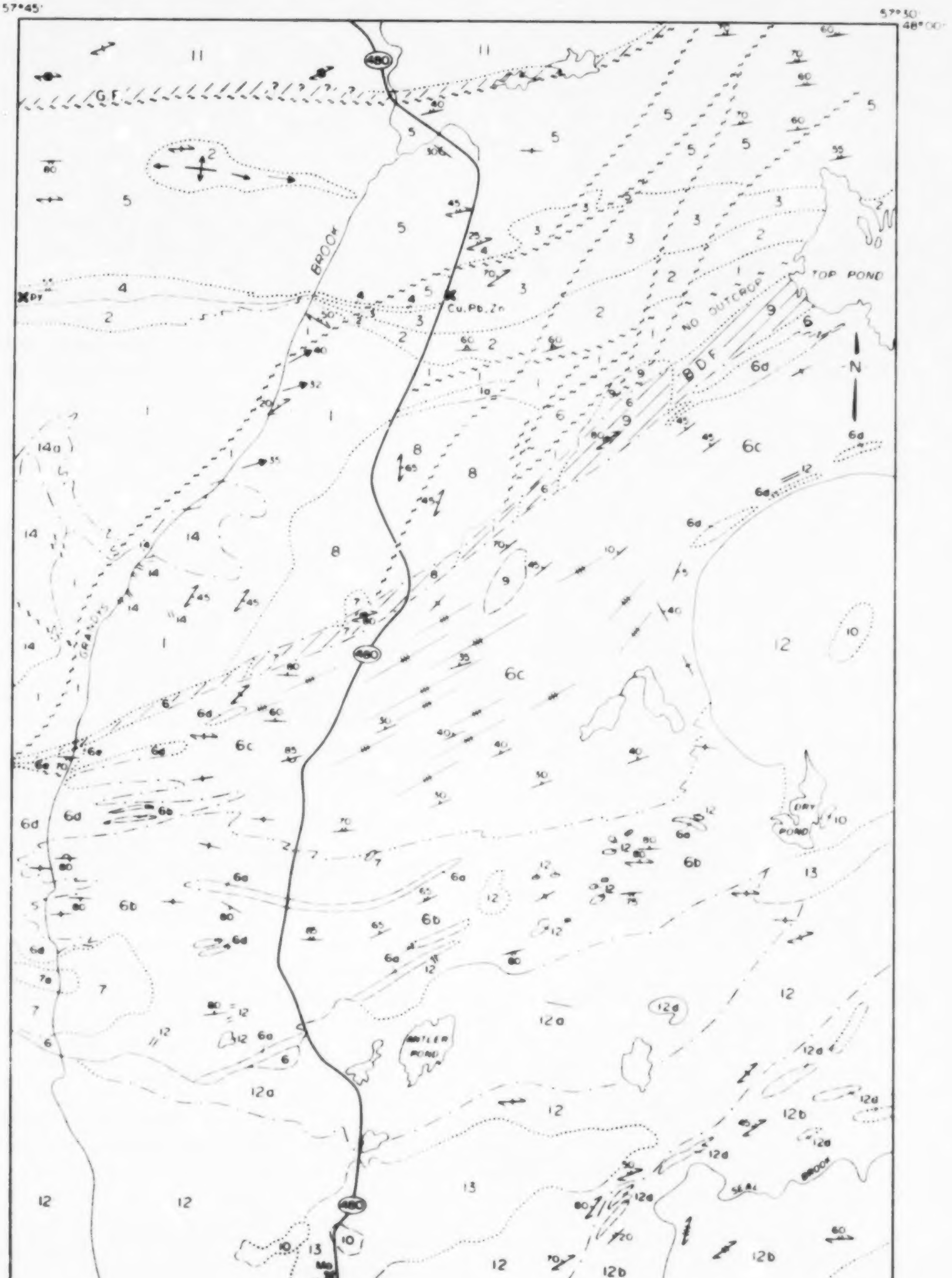
GEOLOGICAL SETTING

The eastern half of the Peter Snout map area is underlain by six major geological units of Lower Ordovician(?) to Devonian(?) age. With the exception of the late to post-tectonic granitoids, these units trend east-west to northeast across the map area. A northeast trending mylonite zone, the Bay d'Est Fault (Cooper, 1952), bisects the area. A marked contrast in facies development and metamorphic grade is evident across this fault.

North of the Bay d'Est Fault, the succession includes pyroclastic volcanics and marine sediments cut by foliated granitoid rocks. The volcano-sedimentary rocks lie along strike from and are continuous with the Bay du Nord Group to the southeast (Cooper, 1954; Chorlton, 1980a, b). An east-west trending zone of mylonite, informally named the Gunflap Hills fault (Chorlton, pers. comm., 1982), separates the Bay du Nord Group to the south from the Buck Lake Granite (Kean and Jayasinghe, 1981). This granite underlies the northernmost part of the Peter Snout area and is continuous into the extensive granite/ migmatite terrane to the north (Kean and Jayasinghe, 1981). To the south, the Bay du Nord Group is in contact with foliated tonalite and a mylonitic feldspar megacrystic granite. The contact is not exposed but an intrusive relationship with Bay du Nord volcanics is probable. The Bay du Nord Group is post-tectonically intruded by the Peter Snout granite.

South of the Bay d'Est Fault, the succession includes weakly metamorphosed and relatively little deformed clastic rocks intruded by a late to post-tectonic intrusive suite. This clastic sequence is indicative of fluviatile and shallow marine deposition and contains major volcanic intercalations only in its easternmost and westernmost extent.

Contribution to Canada-Newfoundland co-operative mineral program 1982-84. Project carried out by Newfoundland Department of Mines and Energy


57°45'
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G F
B D F
NO OUTCROP
TOP POND
Cu.Pb.Zn
PY
BROOK
GRANDYS
DRY POND
ANTLER POND
SEAL BROOK
N
480
0
5 km

DEVONIAN OR EARLIER

"PETER SNOUT GRANITE"

14 Pink muscovite-biotite and biotite, locally garnetiferous equigranular granite and associated aplite and pegmatite dykes. **14a**: same as above but with numerous screens of Bay du Nord Group metasedimentary and metavolcanic rocks.

BURGEO BATHOLITH

13 Biotite poor, porphyritic to equigranular, medium to locally coarse grained granite and adamellite; porphyritic grey and pink garnetiferous aplite.

12 Coarse grained, pink and grey, coarse grained K-feldspar porphyritic biotite-rich granite, with subordinate amounts of biotite tonalite and rare granodiorite/adamellite; **12a**: same as above, but with numerous screens and roof pendants of metasediment, migmatite and paragneiss; **12b**: polydeformed medium and coarse grained, pink and grey porphyritic, locally recrystallized biotite granite; fine grained leucocratic granite; **12c**: recrystallized and locally migmatitic fine grained leucogranitoid with numerous amphibolite inclusions and coarse grained pegmatite dykes; **12d**: coarse grained biotite schist, paragneiss and migmatite.

BUCK LAKE GRANITE

11 Fine to medium grained equigranular biotite granite with local coarse grained porphyritic phases.

SILURIAN OR EARLIER

10 Fine to medium grained gabbro, diabase and related metabasic rocks.

9 Massive to predominantly mylonitic, pink feldspar porphyritic granitoid.

8 Medium grained hornblende (± biotite) rich, equigranular tonalite.

ORDOVICIAN OR EARLIER

ROTI GRANITE

7 Medium grained, grey to pink biotite (± rare muscovite); **7a**: fine to medium grained gabbro.

LA POILE GROUP

6 Fine to medium grained, cross bedded feldspathic sandstone and conglomerate; **6a**: angular, quartz pebble and quartz granule conglomerate; **6b**: medium to coarse grained quartz arenite with subordinate feldspathic sandstone; **6c**: thickly bedded, internally cross-laminated feldspathic and quartzofeldspathic arenite; rare granule conglomerate and quartz rich siltstone; **6d**: ash flow tuffs and related epiclastic and pyroclastic rocks; **6e**: massive to amygdaloidal mafic flows.

BAY DU NORD GROUP

5 Predominantly black and grey sandstone, siltstone, shale, slate and phyllite; rare granule to pebble conglomerate.

4 Feldspathic sandstone and bedded tuffs; black slate and phyllite.

3 Cobble to boulder conglomerate, black slate and phyllite, grey siltstone. Contains rare tuffaceous zones several metres above its base.

2 White, cream, grey and pink felsite, rhyolite and welded tuffs.

1 Predominantly felsic volcaniclastic rocks: ash flow tuff and rhyolite; biotite schist and related metavolcanic rocks of pyroclastic origin; **1a**: gabbro boulder conglomerate.

These clastics are traceable along strike to the southeast into the volcano-sedimentary La Poile Group (Cooper, 1954) with which they are tentatively correlated. The La Poile Group sediments are intruded, essentially post-tectonically, by a variety of intrusive and other igneous rocks known collectively as the Burgeo Batholith. The batholith contains two major granitoid phases. Gabbroid rocks that occur as roof pendants within the batholith may be either intrusive in origin or related to ophiolitic gabbros exposed to the west (Chorlton, 1980a). Large metasedimentary screens and/or rafts are widespread through the coarse grained porphyritic phase of the batholith. Recrystallized granitoids in the southeastern extremity of the area may represent either early phases of the batholith or an older predeformed intrusion.

The succession to the north of the Bay d'Est Fault was metamorphosed under mid-greenschist to amphibolite facies conditions. Earliest recognizable structures are recumbent and these are refolded on generally upright axial planes. The La Poile Group has been metamorphosed under biotite grade greenschist facies conditions. Large scale folds are absent. Cordierite is developed in the thermal aureole of the Burgeo Batholith.

The ages of rocks in the Peter Snout area are unknown. The Bay du Nord Group volcanics to the southwest have been isotopically dated at 449 ± 20 Ma (U/Pb zircon, reported in Chorlton, 1980b). The La Poile Group in the same area has been dated at 459 ± 18 Ma (Rb/Sr isochron, reported in Chorlton, 1980b).

STRATIGRAPHY

Bay du Nord Group (Units 1 to 5)

The Bay du Nord Group was described by Cooper (1954) as a sequence of dominantly metasedimentary rocks exposed in two belts in La Poile Bay and Garia Bay on the southwest coast of Newfoundland. He included in the group a sequence of sedimentary rocks containing Devonian plant fossils (Dorf and Cooper, 1943). Chorlton (1980b) redefined the Bay du Nord Group, separating the fossil bearing sequence from the remaining belt of polydeformed and metamorphosed volcanic and sedimentary rocks, migmatites, amphibolites and subvolcanic granites. Chorlton extended the group northwestwards from La Poile Bay as far as the western half of the Peter Snout map area. The volcanic and sedimentary rocks and their metamorphic equivalents, which underlie much of the map area between the Bay d'Est and Gunflap Hill faults, form the northeastern extension of the Bay du Nord Group and are thus correlated with it.

In the eastern half of the Peter Snout area, the group is tentatively subdivided into five units. From base to top these include: a lower succession of ash flow tuffs and epiclastic rocks together with their metamorphic equivalents (1) with a distinctive gabbro boulder conglomerate (1a), felsite, rhyolite and densely welded tuff (2), bedded tuffs and graphitic phyllite (3) and an upper succession of black slate, phyllite, conglomerate and graphitic schist (4) and well bedded gray siltstone, shale and subordinate conglomerate (5).

The Bay du Nord Group is faulted against the La Poile Group and the Buck Lake granite, and is post-tectonically intruded by the Peter Snout granite. An intrusive contact between the Bay du Nord Group and tonalitic and granitic rocks of Units 8 and 9 is inferred. The Bay du Nord Group is interpreted to represent a facies variant and approximate time equivalent of the La Poile Group to the south (see below).

Unit 1

Unit 1a is a boulder conglomerate unit which locally separates the Bay du Nord Group volcanics from tonalite of

Unit 8. The conglomerate is interpreted to represent the lowest stratigraphic level of the Bay du Nord Group in the area.

The conglomerate has well rounded clasts, and is poorly sorted and polymict. Its diagnostic feature is the gabbroic detritus which, in places, forms up to 50% of a single outcrop ridge. The conglomerate also contains clasts of high level granitoid porphyry and a variety of diabasic and metabasic clasts. Several small clasts of probable trondhjemite composition were noted.

The conglomerate faces upwards into, but is faulted against welded and unwelded ash flows of Unit 1. The conglomerate is not traceable west of Route 480. Its maximum thickness is in the order of 100 m.

The extent of gabbroic detritus in the conglomerate may be interpreted as an indication of a gabbroic (ophiolitic?) substrate to the Bay du Nord Group in this area. In hand specimen, gabbroic clasts from Unit 1 are indistinguishable from the ophiolitic gabbros of the Blue Hills of Couteau, 15 to 20 km to the west.

The diagnostic rock types of the remainder of Unit 1 are pyroclastic and epiclastic volcanic rocks and their metamorphic equivalents. Massive flows are rare, and are exposed only in a narrow belt west of Route 480. The volcanism is almost exclusively felsic to intermediate (dacitic) in nature; less than 1% of the Bay du Nord Group volcanics in the area are of mafic composition.

The volcaniclastics are highly strained throughout and in most areas have been metamorphosed to streaky biotite schist. The biotite schists are lithic rich, quartz- and feldsparphyric and they display a diagnostic ferromagnesian lineation. Pegmatite veins and tourmaline veinlets are common in exposures near the Bay d'Est Fault and adjacent to the Peter Snout granite (Unit 14). Pegmatitic patches are widespread throughout the belt.

The epiclastic rocks of Unit 1 are unseparated from the pyroclastic rocks at 1:50,000 scale. The epiclastics occur as small, discontinuous lentils within the tuffaceous units. Where strongly metamorphosed, these rocks have a pronounced biotite-defined banding.

Massive, densely welded tuffs are not readily identifiable in Unit 1. Many of the pyroclastic rocks, however, are tentatively interpreted to be of ash flow and possibly air fall origin.

Unit 2

Unit 2 forms the upper part of the Bay du Nord volcanic succession in the western part of the map area. The unit varies in lithology along strike, but is most commonly massive in nature, being dominated by felsite, rhyolite and welded tuff. It is best exposed in a south-flowing river in the northwestern corner of the area. Other exposures occur in Grandy's Brook and in one of its tributaries. A large antiformal structure at the Stag Ridges (Fig. 1) is underlain by gray, quartz-phyric tuffs which are tentatively assigned to Unit 2. The welded tuffs of Unit 2 are mostly crystal-lithic in composition and vary in grain size from lapilli to fine ash tuffs. The massive welded tuffs and rhyolites are quartz porphyritic; quartz has a diagnostic blue color and is present as ca. 1 mm phenocrysts. Feldspar crystals are 1 to 2 mm in length. The extent of the massive rhyolite is unclear as, in hand specimen, these rocks are often indistinguishable from densely welded tuffs.

Unit 3

In the eastern half of the map area, Unit 2 welded tuffs are succeeded to the north by a succession of bedded tuff, minor graphitic schist, and rhyolite tuff. Although it is tentatively interpreted to overlie Unit 2, Unit 3 may include within it unseparated parts of overlying and underlying units.

The bedded tuffs are planar bedded, feldspar-rich siliciclastics; a strong planar parting is diagnostic. The rhyolitic tuffs have a streaky appearance, but lack the metamorphic character of Unit 1. These tuffs are tectonically interleaved with minor amounts of graphitic pelite and phyllite.

Unit 4

Unit 4 forms the base of the Bay du Nord clastic succession. It disconformably overlies Unit 2 and its contact is defined by cobble to boulder conglomerate. The conglomerate contains a variety of felsic volcanic and high level intrusive clasts but no previously deformed detritus. It is not considered to represent a major structural break within the succession. Above the conglomerate, the succession is essentially entirely clastic; a 1 m thick tuffaceous bed occurs several metres above the basal conglomerate. The main rock types of Unit 4 are fine grained, pyritic black shale, slate and graphitic schist. East of Route 480, Unit 4 may be continuous into the tuffaceous feldspathic sandstone and phyllite of Unit 3, representing a time equivalent facies variant of the latter.

Unit 5

Unit 5 consists mainly of interbedded gray and black sandstone, siltstone, shale and their metamorphic equivalents. Granule to pebble conglomerate is relatively uncommon, and occurs only as thin beds. Some of the conglomerate units are of several hundreds of metres lateral extent. Unit 5 lies to the north of the main belt of Unit 4 and is interpreted to overlie it. This unit forms most of the Bay du Nord Group clastic succession within the area.

In areas of least deformation, the finer grained clastics are characterized by thin, regular and planar bedding; grading is only locally developed in the coarser siltstone beds. Coarse grained siltstones are interbedded with 1 to 5 mm shaly beds. The siltstones are parallel-laminated on a millimetre scale. Rare granule conglomerate forms beds of several millimetres to 50 cm thickness.

A significant boulder conglomerate bed occurs with the lower parts of Unit 5. The bed has a maximum thickness of approximately 4 m. The conglomerate is matrix-supported and unsorted, containing up to 70% shaly matrix. Clasts vary in size from <1 mm to approximately 20 cm; they are generally well rounded in section but are strongly flattened in the plane of foliation. The most prominent clasts are high level granophyre/granite, felsite and (?) volcanic rocks. At least one clast has a pronounced compositional banding. The most notable feature of this conglomerate is the abundance of clasts containing an early, locally cataclastic foliation. The significance of the clasts is discussed below.

La Poile Group (Unit 6)

Cooper (1954) first used the name La Poile Group to designate those volcanic and sedimentary rocks in the La Poile - Cinq Cerf area that lay to the south of the Bay d'Est Fault, and which were truncated against the Chetwynd Granite. Chorlton (1978) redefined the group, and extended it to the northeast dividing it into a sequence of volcanic and sedimentary rocks named the Georges Brook Formation and a subvolcanic pluton named the Roti Granite.

The dominantly sedimentary succession that underlies the part of the map area between the Burgeo Batholith and the Bay d'Est Fault forms the northeastern extension of the volcano-sedimentary belt referred to by both Cooper (1954) and Chorlton (1980b) as the La Poile Group. Although these sediments are here considered to be a facies variant of the Bay du Nord Group, they do occur as a lithologically distinctive unit within the map area. For the purposes of this report and until further study can ascertain its relationship to the Bay du Nord Group, the name La Poile Group will be retained to designate these rocks.

Unit 6

Unit 6 includes all the clastic rocks within the La Poile Group and constitutes approximately 90% of its outcrop area. It forms a west facing sequence that can be subdivided into several facies, some of which are of stratigraphic significance. In the eastern and western extremes of the map area, the clastics either interdigitate with or onlap the volcanic facies of the La Poile Group.

Units 6a and 6b together form the stratigraphically lower half of the clastic succession. Xenoliths and large roof pendants of these units are present within the Burgeo Batholith, up to 5 km south of the contact with the La Poile Group. Unit 6a occurs as two distinct bands within unit 6b.

The diagnostic rock types of Unit 6a are angular, poorly sorted, locally cross-bedded, quartz bearing granule and cobble/boulder conglomerate. Angular clasts of vein quartz, up to 15 cm in diameter, are supported by a quartz-rich sandy matrix. Between 80 and 90% of the detrital assemblage of this unit is vein quartz; other detritus includes rhyolite porphyry, leucocratic granophyre, diabase and sandstone.

Unit 6b consists of medium and coarse grained, blue quartz rich, immature arenaceous sandstone, pebbly sandstone and fine grained granule conglomerate. The sandstones include quartz arenite, feldspathic arenite and feldspathic lithic arenite. Unit 6b sandstones are massive to thickly bedded, internally cross-bedded and very rarely planar-bedded. The granule conglomerates contain clasts of quartz porphyritic biotite granite, pink equigranular granite, rhyolite, aplite, diabase and vein quartz.

Unit 6c overlies Units 6a and 6b and constitutes most of the upper half of the La Poile Group in this area. Its main rock type is gray, fine to medium grained feldspathic sandstone. It is finer grained, less quartz rich and more mature than the lower parts of the group and does not contain the thick conglomerate lenses and beds that are common elsewhere in Unit 6. It is extensively crossbedded; foresets are locally defined by detrital magnetite and more commonly by fine grained granule conglomerate. Planar bedding is locally developed in some of the upper parts of 6c. The beds display crude grading with parallel lamination development. The uppermost levels of 6c are quartz-rich but very fine grained and may be quartzite.

Unit 6d includes the felsic volcanic rocks of the La Poile Group. These are almost exclusively volcaniclastic in nature and mainly restricted to the easternmost part of the La Poile Group where they interdigitate with immature arenites and conglomerates of Unit 6b. To the west the volcanic facies of 6d grades into the clastic facies of 6b. Further to the west on 11P/13W, the volcanic facies predominates (Chorlton, 1980a); there, volcanic centres within the La Poile Group have been identified (Chorlton, pers. comm., 1979).

The main rock types in Unit 6d are ash flow tuffs and lahars and related epiclastic rocks. The ash flows are welded, quartz phyric and of apparent rhyolitic and rhyodacitic composition. They are associated with a sequence of laharic breccias, which fine rapidly eastwards. These are presumably related to volcanic activity to the west, where the ash flow tuffs predominate. The welded ash flows are not extensively developed to the east of Grandy's Brook where the volcanics are either of air fall pyroclastic or epiclastic origin. These may represent the distal facies variants of the lahars to the west.

Unit 6e exclusively consists of mafic volcanic rocks and related hypabyssal intrusives. The flows are feldspar porphyritic and locally coarsely amygdaloidal, and are locally intruded by massive metabasic rocks.

Intrusive Rocks

Unit 7

Unit 7 forms the eastern extension of the Roti Granite of Chorlton (1980a). In the western half of the Peter Snout area, the Roti Granite is intrusive into the La Poile Group but also occurs as a major detrital component within the sedimentary succession of the group. In view of this relationship, Chorlton (1979) has interpreted the granite as a subvolcanic pluton, genetically related to La Poile Group volcanism.

In the map area, Unit 7 intrudes both the clastic (6b) and volcanic (6d) facies of the La Poile Group. The main phase of the granite is gray to pink, medium grained, equigranular biotite granite. A small gabbroic intrusion (7a) is exposed within the boundaries of the granite; its relation to the Roti Granite is unclear.

Unit 8

Unit 8 is a black and white, medium grained, equigranular hornblende biotite tonalite. It occurs within and to the north of the Bay d'Est Fault and is interpreted to intrude syntectonically the Bay du Nord Group. Nevertheless, little evidence of an intrusive contact remains exposed. The tonalite is foliated in most areas and is mylonitized along the Bay d'Est Fault. It contains cognate xenoliths of granodiorite and diorite and accidental xenoliths of gabbro. The tonalite is cut by gray aplite and more rarely by metabasic dikes.

Unit 9

Unit 9 is a pink, K-feldspar porphyritic, fine grained granite that occurs as two separate intrusions within and to the south of the Bay d'Est Fault. It intrudes both the Bay du Nord and the La Poile Groups and is extensively mylonitized along the Bay d'Est Fault. It contains zones of mylonitic felsic volcanics within its boundaries.

Unit 10

Unit 10 includes all gabbroic rocks within the map area, other than those associated with the Roti Granite. The gabbros occur in four separate areas, all as roof pendants within the "Burgeo Batholith". They are medium to coarse grained, massive to foliated, altered and hornblende bearing. It is unclear at present whether the gabbroic rocks are intrusive in nature or related to the ophiolitic gabbro terrane to the west (cf. Chorlton, 1980a). If the latter is the case in this area, then these gabbros would represent the oldest succession within the area.

Unit 11

Unit 11 is a granitoid intrusive that underlies that part of the map area north of the Gunflap Hill fault. It forms the southern extension of the Buck Lake granite of Kean and Jayasinghe (1981). It is faulted against the Bay du Nord Group along the Gunflap Hill fault. Unit 11 consists primarily of fine to medium grained biotite granite. A coarse grained porphyritic granite phase occurs in the northern extremity of the area; this phase is much more extensive to the north (Kean and Jayasinghe, 1981) where it represents the main phase of the Buck Lake granite. The granite is strongly mylonitized along the Gunflap Hill fault.

"Burgeo Batholith"

The informal name "Burgeo Batholith" was used by Williams (1978) to designate the large granitoid terrane which extends from Connoire Bay to La Hune Bay, on the south coast of Newfoundland. For the purposes of this report, that name is retained for the late to post-tectonic intrusive suite, which underlies the southern parts of the area. In the map area, the "Burgeo Batholith" can be divided into two major phases.

Unit 12

The major rock type of Unit 12 is massive, coarse grained, biotite-rich, K-feldspar porphyritic granite. The granite is characterized by euhedral and subhedral orthoclase phenocrysts up to 6 cm in length. This phase is predominantly biotite-rich but it does contain irregularly shaped biotite-poor zones. Small areas of biotite tonalite are also included in Unit 12. The tonalite is equigranular, coarse grained and dark gray. Unit 12 granitoids are cut by numerous pink and gray, quartz porphyritic aplite dikes; dikes of more mafic composition are rare.

Unit 12a differs from Unit 12 only in that it contains numerous xenoliths, screens and roof pendants of La Poile Group metasediment and related migmatite.

Unit 12b consists of deformed granitoid with extensive zones of metasediment. It is interpreted as being gradational into Unit 12. The main rock type is a highly strained, coarse grained feldspar porphyritic granite. The granite is gradational into zones of finer grained granitoid and aplite. The finer grained granitoid is in places recrystallized.

Unit 12c underlies the southeasternmost corner of the map area. It consists of a fine grained, recrystallized, predominantly leucocratic granitoid with numerous, small amphibolite and metasediment xenoliths. Its relation to the remainder of the Burgeo Batholith is unclear. It is presumed to be relatively older than the other Unit 12 granitoids but its absolute age is unknown. Unit 12c is cut by numerous pegmatite dikes.

Unit 12d includes the metasedimentary xenoliths that are present in Unit 12b. The metasediments occur in northeasterly elongated roof pendants, the largest of which is approximately 1 km in length. The protolith of these rocks is considered to be, in part, La Poile Group clastics. The major rock types in the roof pendants are coarse grained biotite-schist and banded migmatite.

Unit 13

Unit 13 consists of pink, coarse grained, equigranular to slightly porphyritic, biotite-poor granite and pink, garnetiferous, quartz porphyritic aplite. In most areas, Unit 13 is clearly intrusive into Unit 12, but locally the contact appears to be gradational.

Unit 14 (Peter Snout granite)

Unit 14 contains fine and medium grained pink, equigranular, biotite ± muscovite granite. It post-tectonically intrudes the Bay du Nord Group; the contact with adjacent volcanics is exceptionally diffuse and irregular. The granite contains small irregularly shaped zones of more tonalitic composition and numerous muscovite-bearing garnetiferous pegmatites.

STRUCTURAL AND METAMORPHIC EVENTS

The Bay d'Est and Gunflap Hills faults divide the region into three belts of contrasting structural and metamorphic style.

The northerly and least extensive of the belts is characterized by cataclastic fabrics and extensive migmatization. The migmatites are not exposed in the Peter Snout map area, but are extensively developed in the northerly adjacent King George IV Lake map area. This belt is interpreted to represent deeper structural levels of the Bay du Nord Group than are exposed to the south.

The succession between the Gunflap Hills and Bay d'Est Faults has been polydeformed and metamorphosed under amphibolite facies conditions. The characteristic migmatites of the northern belt are absent. Evidence of earliest deformation is preserved in the predeformed detritus in the conglomerates of Unit 5 of the Bay du Nord Group. The extent and nature of this early deformation is uncertain. There is no structural break between the Bay du Nord Group sediments and the underlying volcanics, and the basal conglomerate of the sedimentary sequence contains no previously deformed volcanic or plutonic detritus. It is suggested that the predeformed clasts are related to localized synvolcanic tectonism, active during evolution of the Bay du Nord volcanic arc.

The Bay du Nord Group has been affected by early recumbent structures that have been refolded on upright northeast trending axes. The prominent structural feature of the lower, volcanic units of the group is a northeasterly trending shallow to moderately northeast plunging lineation.

The succession to the south of the Bay d'Est Fault has been openly folded and metamorphosed under greenschist facies metamorphic conditions prior to the intrusion of the Burgeo Batholith. Both the La Poile Group and the Burgeo Batholith have been affected by late faulting and shearing. Within the Burgeo Batholith, a progressive increase in deformation towards the southwest is evident. This presumably is related to either late and/or inhomogeneous deformation, although older granitoids may be present in that area.

The Bay d'Est Fault (Cooper, 1954) is a major mylonite zone in this map area and it juxtaposes amphibolite facies volcanics of the Bay du Nord Group against greenschist facies sediments of the La Poile Group. The fault is a high angle reverse structure. In the map area, the facies contrast across the fault is obvious; however, facies similar to the La Poile Group do occur on its northern side. Further to the southwest, volcanic and sedimentary facies have been traced across the structure (Chorlton, 1980a).

The Gunflap Hill fault is a late high angle reverse fault that postdates the deformations in the Bay du Nord Group. Like the Bay d'Est Fault, it has a pronounced cataclastic fabric. Chorlton (1980a, pers. comm., 1982) has shown the fault to be a splay of the Cape Ray Fault.

MINERAL EXPLORATION POTENTIAL

The potential for the discovery of significant mineralization within the map area is high. Possible exploration targets are base metals, uranium and molybdenum.

The Bay du Nord Group represents the southern extension of the central Newfoundland island arc (Chorlton, 1980), and thus should be seriously considered as favourable for massive sulfide exploration. Furthermore, the fine grained rocks in the upper parts of the Group are a potential target in the exploration for sediment-hosted sulfide deposits. Examples of both styles of mineralization have been documented within the Bay du Nord belt. The volcanic facies of the La Poile Group, of minor extent in the map area, has a similar potential for massive sulfides.

Known uranium showings in the western half of the Peter Snout area lie within the western extension of the Bay du Nord Group. The stratiform nature of at least two of these showings makes the Bay du Nord Group an excellent exploration area for volcanogenic uranium mineralization. The two-mica granites of Unit 14 are also potential targets for uranium and other rare element mineralization.

Much of the Burgeo Batholith is of little economic interest at present. Molybdenite mineralization is known within fine grained granite and aplite of Unit 13. Pegmatite dikes within the batholith may also be of some economic interest.

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NAIN-CHURCHILL PROVINCE CROSS-SECTION, NACHVAK FIORD, NORTHERN LABRADOR

by

R.J. Wardle

ABSTRACT

The Nain-Churchill boundary is a broad zone of progressive structural reworking in which Archean crust may be traced for at least 25 km into the Churchill Province. The Nachvak Fiord section of the boundary zone is divided into three structural zones: Nain Province, Churchill Border Zone and Churchill Inner Zone.

The Nain Province consists of Archean crust for which the following history is recognized:

1. *Formation of early mafic gneisses, locally associated with supracrustal gneisses;*
2. *Widespread intrusion of granitoid plutons incorporating early mafic gneisses as inclusions;*
3. *Regional deformation, migmatization and granulite grade metamorphism circa 2.8 Ga; formation of Nachvak gneiss;*
4. *Intrusion of Kammarsuit granite circa 2.7 Ga;*
5. *Zonal mylonitization and retrogression circa 2.6 - 2.5 Ga;*
6. *Intrusion of regional post-tectonic mafic dyke swarm circa 2.4 Ga.*

The predominant rock type in the Nain Province is Nachvak gneiss which has been subjected to static amphibolite-greenschist facies retrogression during late Archean and Hudsonian metamorphic events.

The Churchill Border Zone is underlain predominantly by the granitoid Nachvak gneiss but also contains lower Proterozoic sediments of the Ramah Group deformed in the Hudsonian Orogeny. Hudsonian deformation in the gneiss is restricted to zonal reworking in shear zones which change in character from brittle fracture zones in the east to ductile shear zones in the west. The border zone also contains a granulite facies-amphibolite/greenschist facies retrograde isograd, previously thought to be the Nain-Churchill boundary, which marks the western limit of combined late Archean-Hudsonian retrograde alteration. Structural style is that of vertical tectonics and easterly directed overthrusting.

The Churchill Inner Zone contains a westerly extension of the Nachvak gneiss which encloses a linear belt of Archean anorthosite. Nachvak gneiss is bounded to the west by a major belt of quartz + feldspar + garnet mylonitic gneiss (Tasiuyak gneiss) of enigmatic origin. Hudsonian straightening and mylonitic fabrics are pervasive in the inner zone and the late 2.4 Ga dykes have been transposed into the regional fabric. Both western Nachvak and Tasiuyak gneiss have been intensely mylonitized in what may be a major transcurrent shear zone.

INTRODUCTION

Northern Labrador (Figure 1) contains the boundary between Archean gneisses of the Nain Structural Province, stabilized around 2.5 Ga, and lower Proterozoic rocks of the Churchill Structural Province, stabilized following the Hudsonian Orogeny *circa* 1.7 - 1.8 Ga.

As originally defined by Stockwell (1963), on the basis of K-Ar dates, the boundary position lay well west of the position shown on Figure 1. Following regional mapping by Taylor *et al.* (1969, 1970), the boundary was redefined (Taylor, 1971) on structural grounds to the position indicated in Figure 1. Despite occasional criticism (*e.g.* Douglas, 1972), this position of the boundary has been the most commonly accepted since that time (*e.g.* Greene, 1970). Morgan (1975), however, has pointed out that the boundary should lie along the eastern edge of the deformed Ramah Group, a view which has not been recognized in regional maps. On recently published maps for the region (Taylor, 1979), the boundary is shown as a simple line corresponding to the contact between Proterozoic granulite gneisses and Archean amphibolite facies gneisses. Implicit in this work and also in the more local mapping of Morgan (1975) is recognition of the fact that the boundary involves, to at least a limited extent, high grade metamorphic overprinting of Archean crust. Morgan (1975), for example, clearly recognized that Archean gneisses extend into the Churchill Province for several kilometres. Taylor *et al.* (1969, 1970) and Taylor (1979) described a belt of intense mylonitization localized along the eastern margin of the Churchill Province. Bridgwater *et al.* (1973) suggested that it may be a zone of major transcurrent shear, possibly corresponding to a plate boundary.

This paper reports the preliminary results of a study of the boundary zone along the coastal cross-section of Nachvak Fiord. The principal objectives of the study are: (i) to determine the extent to which the boundary zone consists of reworked Archean crust as opposed to new Proterozoic material which may have been added, either by deposition, intrusion or accretion; and (ii) to produce a model for the structural development of the boundary zone.

The work was limited to the shoreline and accessible inland areas around Nachvak Fiord. Work in 1983 will extend the cross-section west to the Quebec-Labrador border.

The study complements an additional project of more regional nature on the boundary zone in the Saglek-Hebron Fiord area (see Figure 1 and Ryan *et al.*, this volume).

REGIONAL SETTING

The principal elements of the Nain-Churchill boundary zone are shown in Figure 1. The northern Nain Province has been investigated in detail only in the region of Saglek Fiord where it has been demonstrated to have a complex crustal history extending from >3.6 Ga to 2.5 Ga and, to have experienced successive reworking at *circa* 3.6, 2.8 and 2.6 Ga (Bridgwater and Collerson, 1976; Collerson *et al.*, 1976; Bridgwater *et al.*, 1978). Elsewhere the northern Nain Province has been defined only as an amphibolite facies gneiss complex which gives undisturbed 'Kenoran' ages (largely K-Ar) of circa 2.5 Ga.

In very early Proterozoic times, *circa* 2.4 Ga, the Nain Province was intruded by a wide-spread post-tectonic mafic dyke swarm (Fahrig, 1970; Taylor, 1974), here referred to as the late dykes.

Nain Province gneisses are overlain unconformably by the lower Proterozoic Ramah Group, a sedimentary succession consisting of a lower, shallow water siliciclastic sequence overlain by a

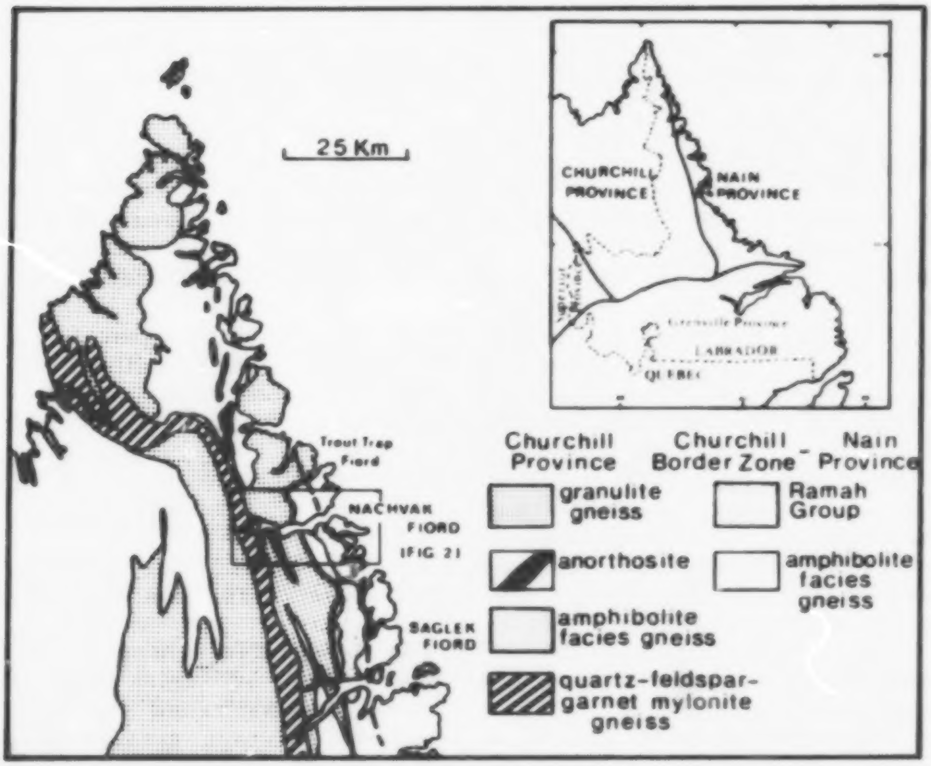

Figure 1 Generalized geology of northernmost Labrador. Simplified after Greene (1970). Position of Nain-Churchill boundary indicated by solid line (Taylor, 1979; Greene, 1970); dashed line, this paper.

deep water argillite-carbonate sequence (Morgan, 1975, 1979; Knight and Morgan, 1981). Morgan (1975) recognized that the Group was extensively affected by cleavage, folding and thrusting during the Hudsonian Orogeny and that the underlying Archean gneisses were also locally reworked and retrogressed in this event; thus, he recognized that the Ramah Group lay within the Churchill Province and that the Nain-Churchill boundary lay along the eastern margin of the group.

The geology of the Churchill Province is known only from the regional mapping of Taylor *et al.* (1969, 1970) and Taylor (1979). The eastern margin of the province in the Nachvak Fiord region is underlain by granulite facies gneisses believed by Taylor (*op. cit.*) to be of Proterozoic age which pass north into amphibolite facies gneisses (Figure 1). To the west these pass into a distinctive quartz+feldspar+garnet mylonite gneiss and then into a further belt of Proterozoic granulite gneisses. Both granulite and amphibolite facies gneisses contain linear belts of anorthosite, also proposed to be of probable Proterozoic age. Anorthosite is not found west of the quartz + feldspar + garnet mylonite gneiss.

As a result of the past season's work, it is evident that as in the case of other structural province boundaries, for example the Grenville Front (Gower *et al.*, 1980), the Nain-Churchill boundary is not a single, simple tectonic feature but rather a broad zone of progressive crustal reworking. In order to describe the effects of this reworking, the Nachvak Fiord region (Figure 2) is divided into three structural zones: the Nain Province, characterized by Archean gneisses with only minimal Hudsonian effects; the Churchill Border Zone in which the Ramah Group has been homogeneously deformed and the Archean basement zonally sheared; and the Churchill Inner Zone in which Archean gneisses have been pervasively deformed and mylonitized during the Hudsonian. Implicit in this division is the recognition that the Churchill Province boundary lies east of the Ramah Group as proposed by Morgan (1975). It is impossible, however, to define a precise eastern limit of the effects of Hudsonian deformation and the boundary between the Churchill Border Zone and Nain Province is necessarily a broad gradational zone.

A key element in recognition of the effects of Hudsonian orogenesis in this region is the behaviour of the late dyke swarm. The structural state of the dykes varies from undeformed, rectiplanar in the Nain Province, to zonally sheared in the Churchill Border Zone, to completely transposed in the Churchill Inner Zone.

The stratigraphy and disposition of rock units within the region are summarized schematically in Figure 3.

NAIN PROVINCE

This is underlain largely by granitoid gneiss of plutonic derivation, referred to here as the Nachvak gneiss, which includes numerous relicts of early mafic and supracrustal gneiss, and which has been subsequently intruded by a late pluton known as the Kammarsuit granite.

Early Mafic Gneisses

These occur as linear inclusions varying from metres to tens of kilometres in length. They vary considerably in composition and texture but generally fall into four types:

(i) Fine grained, massive to weakly banded mafic gneiss with granoblastic texture. These are often intimately associated with supracrustal gneisses and may likewise be of supracrustal or high level intrusive origin.

(ii) Coarse to medium grained mafic gneiss with a compositional variation from ultramafic to leucogabbro, which may locally be recognized as relict igneous layering. This rock type forms the map scale units shown in Figure 2.

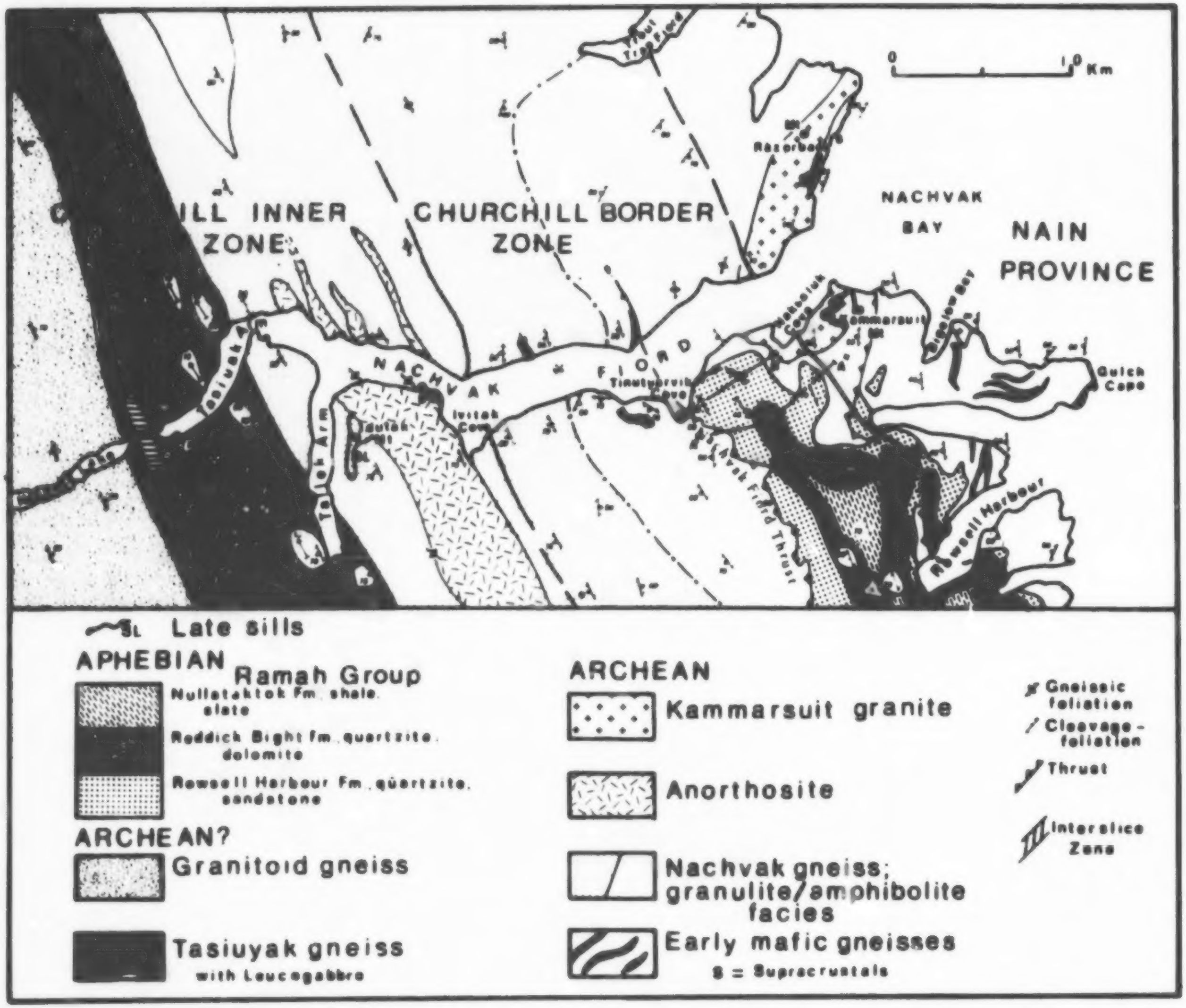

Figure 2 Geology of Nachvak Fiord area. Modified in part from Taylor (1979) and Morgan (1979).

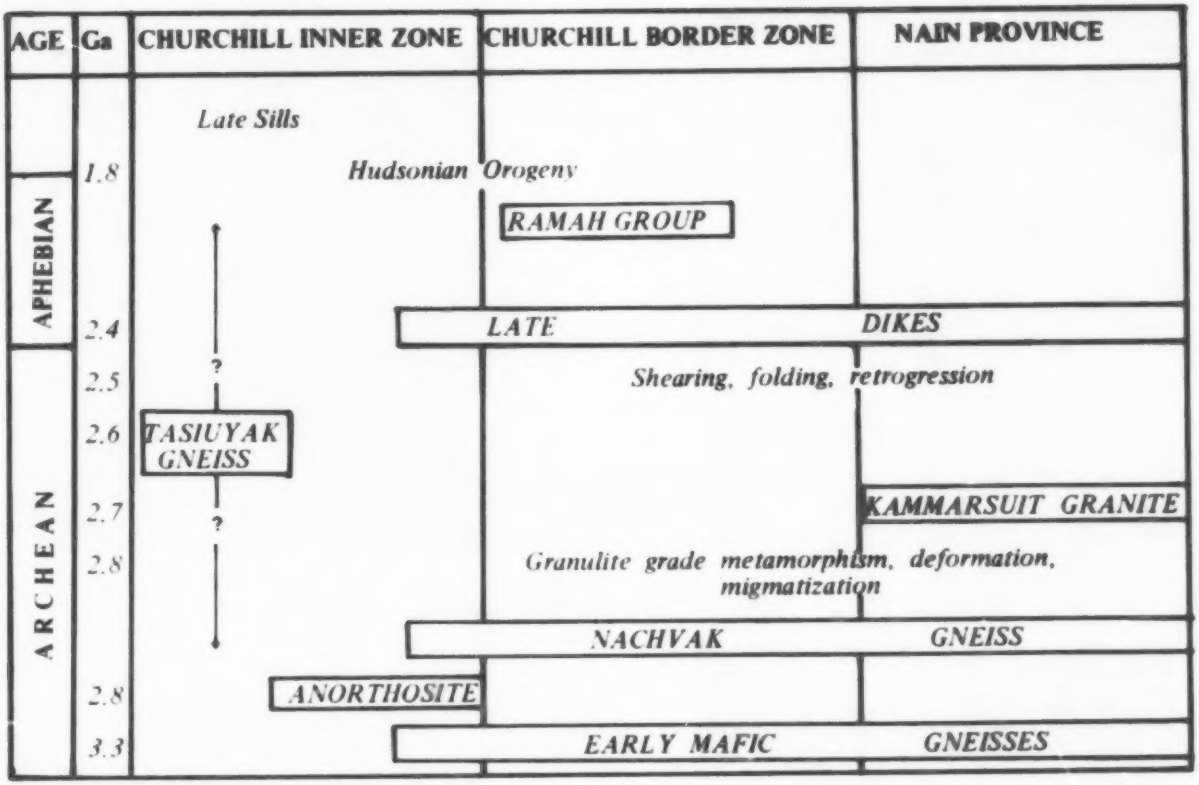

Figure 3   Summary of tectonic development, Nachvak Fiord area.

Plate 1

Plate 2

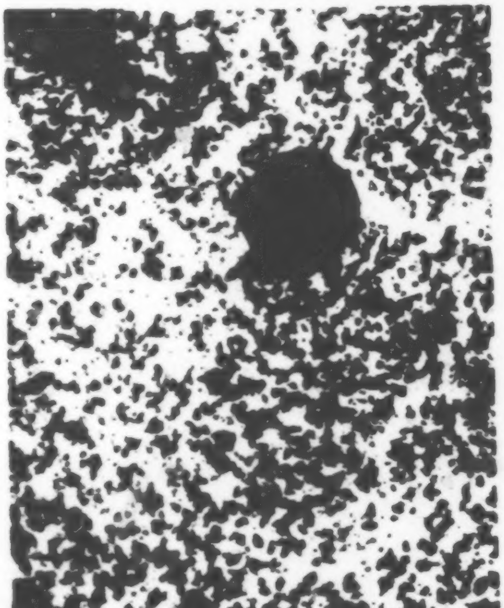

Plate 3

Plate 1 - Early mafic gneiss: screen of migmatitic (type iii) mafic granulite (retrogressed) in non-migmatitic Nachvak gneiss, Gulch Cape. Scale - packsack, 40 cm high.

Plate 2 - Early mafic gneiss: inclusion of massive, black amphibolite (type iv), possibly a pre-tectonic mafic dyke, in migmatitic Nachvak gneiss, north shore Nachvak Fiord, 3 km west of Tinutyarvik Cove. Scale - notebook, 19 cm long.

Plate 3 - Nachvak gneiss: relict igneous texture seen normal to lineation in non-migmatitic granodiorite gneiss, Gulch Cape. Scale - lens cap, 5 cm diameter.

(iii) Highly migmatitic, grey, mafic to intermediate gneiss of dioritic to gabbroic composition. These are found only as small inclusions in Nachvak gneiss (Plate 1).

(iv) Dense, black, granoblastic mafic gneiss found only as small slab-like bodies, apparently the remnants of deformed mafic dykes (Plate 2) intrusive into the Nachvak gneiss protolith.

All types show evidence of granulite grade metamorphism (two pyroxene assemblages), but have been partially retrogressed, together with the host Nachvak gneiss, to amphibolite and greenschist facies assemblages comprising hornblende, secondary brown and green biotite, actinolite, orthoamphibole, and locally chlorite, epidote and calcite.

Some of the migmatitic mafic gneisses (type iii) were clearly migmatized prior to incorporation in the Nachvak gneisses (Plate 1). The type (iv) mafic dyke remnants (Plate 2) were only deformed following incorporation in the Nachvak gneiss. The contacts of other inclusions are usually obscured by partial melting and deformation, and structural relationships with the Nachvak gneiss are uncertain.

The parentage of the mafic gneisses is undoubtedly mixed. The type (i) fine grained and type (ii) metagabbroic gneisses resemble those associated with the pre-2.8 Ga Upernavik supracrustals of the Saglek area (Bridgwater *et al.*, 1975; Collerson *et al.*, 1976), although it is not inconceivable that some could be derived from the pre-3.6 Ga Nulliak assemblage (Collerson *et al.*, *op. cit.*) of the same area.

The origin of the type (iii) migmatic mafic gneisses is uncertain; some are obviously derived from an early gneiss terrane, others may simply be highly metamorphosed and migmatized equivalents of types (i) and (ii). The most obvious candidate for the type (iv) dyke remnants are the *circa* 3.3 Ga Saglek dykes (Collerson *et al.*, *op. cit.*). They do not, however, contain the relict plagioclase phenocrysts typical of Saglek dykes and it is equally possible that they are derived from a younger dyke suite not represented in the Saglek area.

Supracrustal Gneiss

Gneiss of definite supracrustal origin is rare in the area and confined to several narrow screens exposed on the sea cliffs of Mount Razorback and the south coast of Nachvak Bay (Figure 2). These are finely banded, rusty weathering, garnet rich psammitic and semi-pelitic gneisses with thin interbands of metaquartzite or metachert. They closely resemble parts of the *circa* 3.3 - 2.8 Ga Upernavik supracrustal sequence of the Saglek area (Bridgwater *et al.*, 1975; Collerson *et al.*, 1976) and also the equivalent Malene supracrustals of West Greenland (Bridgwater *et al.*, 1976).

Nachvak Gneiss

This is a new term informally applied to the granitoid gneisses which form the predominant rock type in the Nachvak Fiord area. In the Nain Province zone, these are typically gray-green weathering gneisses of granodioritic to tonalitic composition containing numerous inclusions and screens of early mafic gneiss. Near the margins of the larger screens the Nachvak gneiss is characteristically crowded with mafic gneiss inclusions.

The unit is seen in its least metamorphosed state between Bigelow Bay and Gulch Cape where it is locally a strongly foliated to gneissic granodiorite (Plate 3) with augen texture. Elsewhere in the area the granodiorite-tonalite gneiss has been heterogeneously migmatized with production of a fine grained, white, granitic melt fraction (Plate 4).

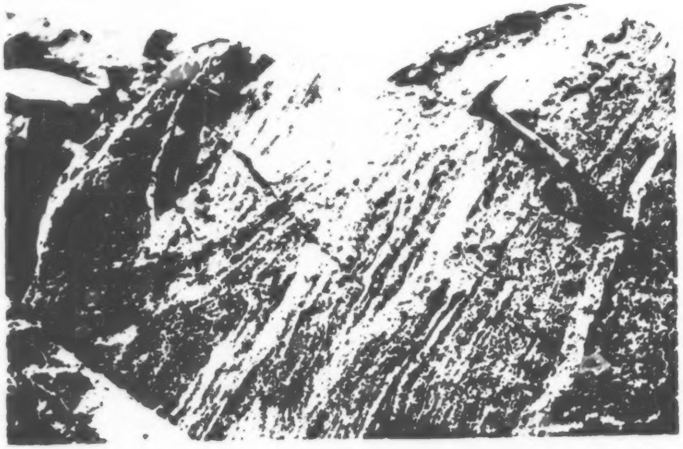

Plate 4

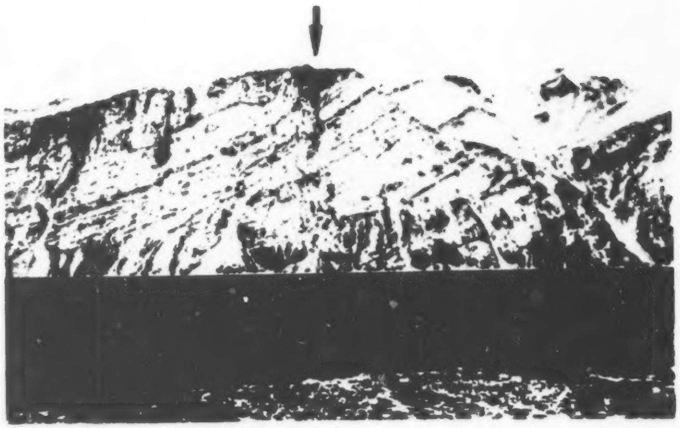

Plate 5

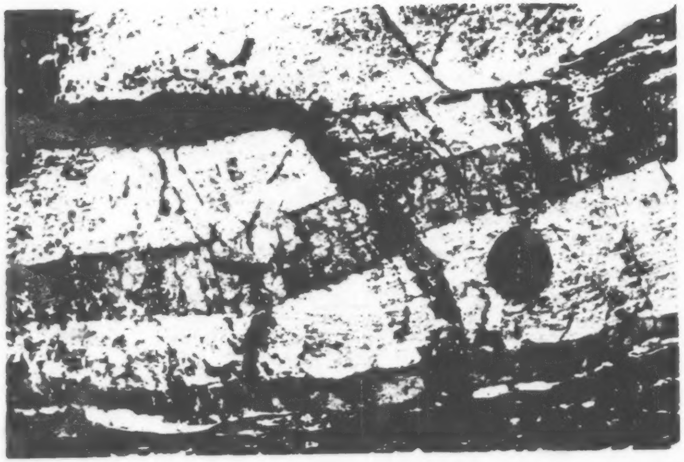

Plate 6

Plate 4 - Nachvak gneiss: migmatitic granodiorite to quartz monzonite gneiss, Bigelow Bay. Scale - hammer, 43 cm long.

Plate 5 - Late dyke swarm. Dykes are largely undeformed with strike 045 - 055° and dip 40 - 55° NW, and cross-cut granulite grade fabrics in Nachvak gneiss. Dyke swarm is cut by Hudsonian shear zone (arrow) in which dykes are rotated to vertical, boudinaged and sheared. Dyke remnants preserved in internal shear augen retain cross-cutting relationships with pre-dyke mylonitic fabrics (cf. plate 6), thereby demonstrating that Hudsonian shearing has occurred by reactivation of late Archean shear zone. Scale - height of fiord wall is 650 m.

Plate 6 - Late dykes cross-cutting mylonitized Nachvak granulite facies gneiss in Churchill Border Zone. Dykes have been recrystallized, foliated and partially transposed during Hudsonian deformation. Location is north shore, Nachvak Fiord, 5 km west of Tinutyarvik Cove. Scale - lens cap, 5 cm diameter.

Textures vary from agmatitic to lit-par-lit. These have been zonally flattened during subsequent deformation into banded gray and white quartzofeldspathic gneiss.

The Nachvak gneiss preserves abundant evidence of early granulite facies metamorphism, associated with migmatization and deformation. Relict assemblages comprise quartz + feldspar + hypersthene + clinopyroxene + hornblende + biotite. Retrogression of this assemblage is visible in outcrop as diffuse green haloes around pyroxene grains and a green coloration of plagioclase. In thin section pyroxene has been internally pseudomorphed by uralitic aggregates of tremolite and orthoamphibole (anthophyllite?) and rimmed by microcrystalline haloes of green biotite intergrown with minor chlorite. Plagioclase is also severely altered to epidote-calcite assemblages.

Structures in the Nachvak gneiss have a general north-south trend, swinging to northeast north of Nachvak Fiord, with steep to moderate westerly dips. Zones of fabric straightening are present but ductile shear zones are absent. A large reclined isocline of migmatitic granite exposed on the the sea cliffs of Mount Razorback represents the only evidence of megascopic folding.

The age of the Nachvak gneiss has not been determined directly; however, a U-Pb zircon age of 2.825 Ga (Morgan, 1979) from Bell Inlet, 23 km south of Gulch Cape, probably approximates the timing of granulite facies metamorphism and represents a minimum age for the unit.

Collerson *et al.* (1982) have proposed most of the granitoid gneisses occurring between Saglek and Nachvak Fiords to be equivalents of the Kiyuktok gneiss of the Saglek area which was formed circa 2.8 Ga by reworking and migmatization of the 3.6 Ga Uivak gneisses.

From this summer's work it is evident that where the protolith of the Nachvak gneiss can be recognized *i.e.* in the eastern part of the area, it was a relatively simple granodiorite-quartz monzonite plutonic rock (Plate 3), very different to the complex banded Uivak gneiss protolith of the Kiyuktok gneiss (see Ryan *et al.*, this volume). Furthermore, the Nachvak gneiss lacks the abundant Saglek dyke remnants which characterize the Uivak and Kiyuktok gneisses. The Nachvak gneiss does contain isolated dyke-like inclusions (type iv) but these are nowhere as abundant as in the Saglek area.

Alternatively (D. Bridgwater, personal communication), it is possible that the Nachvak gneiss, at least in part, is equivalent to the *circa* 2.8 Ga Nuk gneisses of western Greenland (McGregor, 1973; Bridgwater *et al.*, 1976) which are derived from a series of calc-alkaline granitoid plutons intruded *circa* 3.05 Ga (Baddsgard and McGregor, 1981) into older crust represented by equivalents of the Uivak gneiss.

It is conceivable, however, that the more completely deformed and migmatized parts of the Nachvak gneiss, where protolith type is difficult to recognise, may include an Uivak component deficient in Saglek dykes. This would certainly be compatible with the numerous mafic inclusions in the gneiss which suggest derivation by reworking of earlier crustal material.

Further mapping and isotopic work is clearly needed before correlations of the Nachvak gneiss can be confirmed. In particular the critical area between Nachvak and Saglek Fiords needs detailed mapping.

Kammarsuit Granite

This unit was initially recognized by Morgan (1975, 1979) as a distinctive orthogneiss unit on the south side of Nachvak Bay and subsequently named

Kammarsuit gneiss by Collerson *et al.* (1982). It is now recognized that the unit extends well to the north of Nachvak Bay (Figure 2) and that for the most part it is simply a strongly foliated megacrystic granite. In its least deformed state, in exposures around Mount Razorback, the unit is a dark, green-gray megacrystic granite with white weathering K-feldspar megacrysts 2-4 cm long, and bluish quartz. This was locally intruded by later phases of pale gray, coarse grained, more quartz-rich granite and by sheets of pink or white leucogranite. The pluton also includes abundant sheet-like inclusions of early mafic gneiss. A small satellite pluton of equigranular granite, probably related to the Kammarsuit granite, occurs east of Bigelow Bay (Figure 2). Dykes of Kammarsuit granite also intruded Nachvak gneiss along the south shore of Nachvak Bay.

The primary mafic mineral phase of the Kammarsuit granite was evidently pyroxene, possibly in association with hornblende; however, subsequent retrograde metamorphism largely replaced this with pseudomorphic aggregates of green and brown biotite, uralitic tremolite and green-brown hornblende.

Over most of its exposed area the granite is pervasively foliated, with pronounced megacryst alignment, but is neither gneissic nor migmatitic. West of Naksaluk Cove a strong ductile shear fabric was superimposed on the granite to produce a coarse augen gneiss. This deformation predates intrusion of late Archean dykes.

The contacts of the Kammarsuit granite are well exposed on all sides. The eastern contact of the granite, most clearly seen on the north coast of Nachvak Bay, is steep and clearly cross-cuts earlier gneiss and migmatite fabrics of the Nachvak gneiss at a slight angle. The western contact is concordant with structures in the Nachvak gneiss, largely as the result of superimposed late Archean deformation.

Collerson *et al.* (1982) have obtained an Rb-Sr age of 2.693 Ga (+ 148 - 120) for the granite which they believe approximates time of intrusion. They also proposed the granite to be chronologically equivalent to the Nuk gneisses of West Greenland, a correlation which now seems untenable. It is more likely that the Kammarsuit granite is equivalent to late porphyritic granites such as the Ilivertalik granite of West Greenland (Bridgwater *et al.*, 1976) emplaced during or immediately following the main high grade metamorphic event of 2.8 Ga, but prior to the latest phase of regional deformation.

Green Dykes

Several scattered examples have been found of thin, mafic to intermediate dykes with irregular trends and greenish colouration. The dykes cross-cut the gneissic and migmatitic fabrics of the Nachvak gneiss at moderate to shallow angles, but have been recrystallized and partially transposed into the gneissic fabrics during subsequent late Archean deformation. The dykes are composed of fine grained, green hornblende intergrown in granoblastic texture with plagioclase. In terms of their structure the dykes appear to be of similar age to the Kammarsuit granite.

Late Dykes

The late dyke swarm in the Nain Province has an overall east-west trend but local trends may be irregular (Morgan, 1975). Individual dykes are not shown in Figure 2 but their distribution has been mapped by Morgan (1979). In size they vary from less than 1 m to over 100 m in width and vary from basalt to medium grained gabbro. Most of the basalt dykes are aphanitic but plagioclase phyric varieties are common. The great majority of dykes are undeformed and clearly truncate structures in the host Nachvak gneiss and Kammarsuit granite. However, some have suffered minor shearing along their contacts, presumably as a result of

Hudsonian deformation. In thin section, even undeformed dykes show a pervasive static alteration which has partially to completely replaced pyroxene and plagioclase with fine intergrowths of actinolite + chlorite + epidote ± biotite, and calcite + epidote respectively. The effects of this alteration become more pronounced towards the Churchill Border Zone where many of the dykes are fine grained 'greenstones'. These usually lack penetrative fabrics but may locally display crude shear fabrics.

CHURCHILL BORDER ZONE

This zone is underlain by Nachvak gneiss intruded by late Archean dykes and overlain by Ramah Group sedimentary rocks.

Nachvak Gneiss

Nachvak gneiss in this zone is subdivided by an isograd which separates a western belt of granulite facies gneisses from retrograde amphibolite to greenschist facies gneisses in the east (Figure 2). The retrograde isograd corresponds to the Nain - Churchill boundary as defined by Taylor (1979). The granulite grade gneisses are characterized by ortho and clinopyroxene + hornblende + biotite assemblages in both mafic and quartzofeldspathic gneisses, with garnet as an additional phase in mafic granulites. Granulite fabrics in the Nachvak gneiss clearly predate intrusion of late dykes and are therefore of Archean rather than Hudsonian age as implied by Taylor (1979).

The retrogressed gneisses are gray and are contiguous with similar Nachvak gneiss in the Nain Province. Retrograde assemblages indicate a range of metamorphic conditions from amphibolite to greenschist facies and probably result from a combination of late Archean and Hudsonian effects.

The Nachvak gneiss of the Churchill Border Zone differs from that of the Nain Province in the greater development of sheared, straightened and mylonitic gneiss which occurs in zones 3 to 30 m wide. These are characterized by border zones of straightened or protomylonitic gneiss and cores of fine grained mylonite and ultramylonite gneiss. Where migmatitic mafic gneisses have been involved in these zones distinctive black and white or black and pink striped mylonites have been produced by attenuation and transposition of felsic and mafic components. Fabric trends in the Churchill Border Zone are generally northwest with steep to moderate westerly dips. Megascopic and mesoscopic F_2 folds associated with shear zones have strong easterly vergence and shallowly plunging hinge lines.

Contrary to expectation the majority of shear zones in the eastern part of the border zone are cut by undeformed or only mildly brecciated late dykes and are therefore of late Archean rather than Hudsonian age. In some instances the late dykes preserve discordant chilled margins against the Archean mylonites but have been internally sheared and brecciated during Hudsonian reactivation of the shear zones. Hudsonian structures outside of the shear zones are represented by thin reverse faults associated with thin breccia zones and low grade alteration. Bridgwater *et al.* (1975) have mentioned similar late Archean mylonite zones from the Saglek area; equivalent structures of this age are also well known from the southern margin of the Nagssugtoqidian Mobile Belt in Greenland.

In the western part of the Churchill Border Zone the late dykes are more extensively involved in shearing (see below) and it is difficult to distinguish late Archean from Hudsonian effects. Nevertheless within shear augen in these zones the late dykes locally preserve discordant relationships to earlier mylonitic fabrics.

Late Dykes

The dykes in the border zone increase markedly in abundance from east to west and also develop a very regular northeast trend with moderate westerly dips. This is well displayed on the north side of Nachvak Fiord, opposite Ivitak Cove, where approximately thirty percent of the fiord wall is composed of dyke material locally cut by Hudsonian shear zones (Plate 5). In this area, the northeast trending dykes are cut by local sets of vertical north-south dykes. The majority of dykes in the border zone are undeformed but have been internally recrystallized, pyroxene being pseudomorphed by aggregates of green and brown biotite. Shearing of dykes is more abundant in the Churchill Border Zone than in the Nain Province and its effects vary from the production of crude, low grade chlorite + biotite + epidote + actinolite fabrics in the eastern part of the border zone to biotite + amphibole + plagioclase schistosities in the west. Plate 6 illustrates an example of late dykes which have intruded a late Archean shear zone, and then been foliated and partially transposed during Hudsonian reactivation of this zone.

Ramah Group

Only the lower part of the Ramah Group, consisting of the Rowsell Harbour, Reddick Bight and Nullataktok Formations, is present in the Nachvak Fiord area (Morgan, 1975; 1979). The stratigraphy and sedimentology of the group have been well established by Morgan (1975) and Knight and Morgan (1981) and were not re-examined in this study which instead concentrated on the structural aspects of the group.

The structure style of the Ramah Group is illustrated in the cross-sections of Figure 4. The basal unconformity of the Ramah Group dips gently west and overlies a zone of paleo-weathered gneiss and regolith. Above the unconformity in the east, the group is gently west-dipping with a weak sericitic cleavage developed in fine grained rock types. To the west the group becomes increasingly deformed in close folds slightly overturned to the east. These are associated with a strong axial planar cleavage formed by sericite and fine biotite in sedimentary rocks, and actinolite in metadiabase sills.

The western boundary of the Ramah Group is formed by the Nachvak Fiord thrust (Morgan, 1975), a major structure which has transported Nachvak gneiss eastward over Rowsell Harbour Formation. Both gneiss and metasediments are intensely phyllonitized for several metres adjacent to the thrust. The thrust is also locally overlain by a small sliver of Rowsell Harbour quartzite which is either a secondary thrust slice, or more likely a folded invagination of the thrust surface. An unnamed thrust has juxtaposed the basal Ramah Group, together with its unconformity and underlying basement, and the eastern Ramah Group near Rowsell Harbour (Figure 3). Significantly this thrust is located within the basement rather than along the basement-cover interface. A further thrust, here named the Tinutyarvik thrust, is exposed on the south side of Nachvak Fiord where it has duplicated the basal Rowsell Harbour Formation together with its unconformity and underlying paleoweathered basement (Figure 3; Plate 7). For most of its extent, the thrust must lie within the basement and only locally does it cut into the basal Ramah Group. Its geometry (see Figure 4) requires a considerable part of the eastern Ramah Group to be allochthonous. Dolomite breccias of slump or collapse origin have been found at sea level 100 m below the lower Ramah unconformity and indicate that the pre-Ramah erosion surface must have had relief on the order of 100 m or more. This is taken to suggest that the lens of Ramah quartzite preserved below the Tinutyarvik thrust may have originated as a depression fill (possibly a channel) which was sliced off by the thrust (Figure 4). The Tinutyarvik thrust is a blind one in the sense that it never penetrates the overlying sedimentary pile and is a model for similar thrusts which may well underlie the remainder of the western Ramah Group.

CHURCHILL INNER ZONE

The Nachvak gneiss extends into the Churchill Inner Zone where it contains an extensive belt of anorthosite. The western limit of the Nachvak gneiss is formed by a sheared contact with quartz + plagioclase + garnet mylonitic gneiss termed the Tasiuyak gneiss. More granitoid gneisses are present west of this unit but were not examined during this study.

Nachvak Gneiss

The Nachvak gneiss of this zone differs from that of the Churchill Border Zone in that it has been pervasively straightened and mylonitized. Late dykes have been partially to completely transposed into the mylonitic fabrics demonstrating that the fabrics are largely of Hudsonian age.

Hudsonian deformation increased in intensity from east to west towards the contact with the Tasiuyak gneiss and most of the unit west of the anorthosite was converted to mylonite and ultramylonite gneiss locally veined with pseudotachylyte. The mylonitic zones are generally brown weathering with darker brown or black bands representing attenuated bands of mafic granulite. Internally the mylonite fabric comprises a quartz + feldspar + ortho and clinopyroxene + hornblende + biotite assemblage recrystallized into a fine granoblastic-polygonal texture. Mafic mylonites contain red (almandine?) garnet as an additional phase. In a 60 m wide zone adjacent to the Tasiuyak gneiss both felsic and mafic mylonites become markedly garnetiferous.

Hudsonian deformation in the Churchill Inner Zone evidently occurred under largely anhydrous conditions. Intense Hudsonian shearing obscured any evidence of pre-existing Archean mylonitic fabrics in this zone.

Anorthosite

The presence of linear bodies of deformed anorthosite in the eastern Churchill Province was first recognized by Taylor (1979) who assigned them a probable Aphebian age.

The anorthosite at Nachvak Fiord forms a 5 km wide body which divides into several smaller units north of the fiord, an effect which is thought to be due to interfolding with Nachvak gneiss and the northerly plunge of anorthosite under the gneiss.

Strictly speaking, the anorthosite is largely a leucogabbro (mafic content 10-35%), using the terminology of Myers (1973), but varies to ultramafic, layered gabbro and true anorthosite. Much of the unit has been strongly deformed and recrystallized and these terms are used only to indicate composition. The most pristine exposures of the unit are found on its eastern side where cummulate layered gabbro displaying 15-30 cm alternation of graded ultramafic, gabbro and anorthositic layers, is locally preserved. Dark bands of intergrown garnet, orthopyroxene, diopside and hornblende with symmetrical garnet rims are also found concordant with layering and may be either late intrusive or segregation features. Layering is the only primary feature preserved in the gabbro, all igneous textures having been recrystallized to granoblastic polygonal forms.

Elsewhere, the unit is dominated by fine to medium grained, pale gray to brown weathering leucogabbro and anorthosite characterized by folded and boudinaged lenticles of orthopyroxene rimmed by hornblende. In local low strain zones it can be demonstrated that these are derived by attenuation of

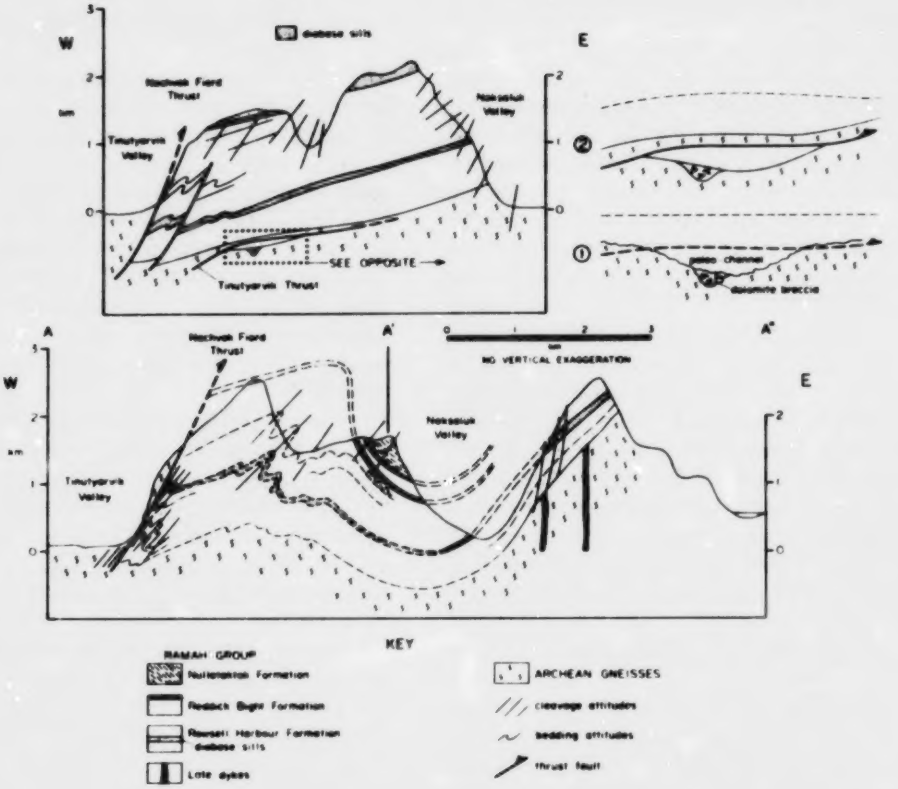

Figure 4 Structural cross-sections of northern Ramah Group, Nachvak Fiord. Sketches 1 and 2 illustrate schematic development of Tinutyarvik thrust (see below).

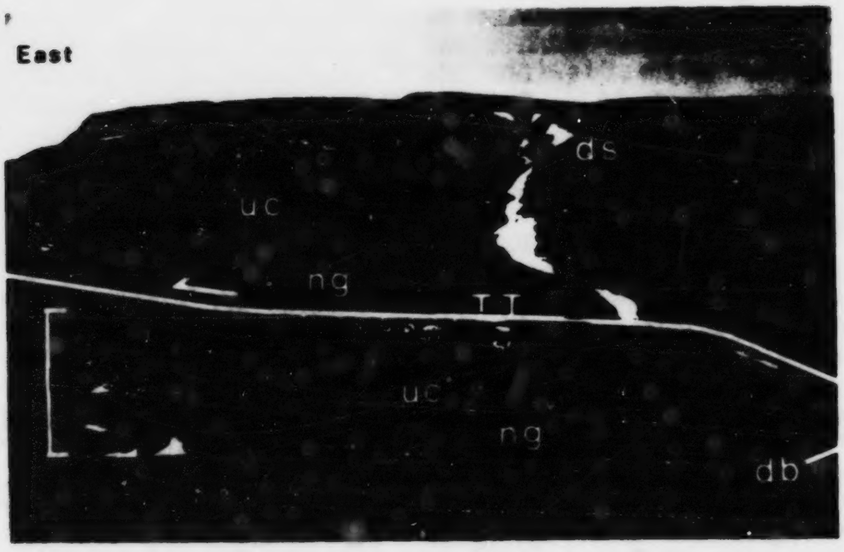

Plate 7 - Tinutyarvik thrust viewed from northwest. ng = Nachvak gneiss; uc - unconformity; rhf = Rowsell Harbour Formation quartzite; TT = Tinutyarvik thrust; ds = diabase sill; db = dolomite breccias found just to right of photo at sea level. Scale - height of section bar is 50 m. Note veiw in photograph is reversed in comparison with that illustrated in Figure 4.

large, 4-5 cm diameter, primary pyroxene megacrysts. Plagioclase usually forms an equigranular polygonal texture with a 0.5 - 1.5 cm grain size, but can also be shown to have formed by recrystallization of much larger igneous feldspars.

Layering in the main body of the anorthosite is uncommon but the unit does contain 1-10 m bands of metagabbro (now mafic granulite) and rare 1 m or less bands of pyroxenite which may be derived from ultramafic layers.

Mafic granulites of metagabbro and leucogabbro derivation are noticeably abundant along the contacts of the anorthosite where they alternate with bands of anorthosite and with sheets of granite gneiss emanating from the Nachvak gneiss. The mafic granulites locally contain a compositional variation possibly derived from igneous layering and are indistinguishable from the type (i) and (ii) mafic gneiss inclusions in the Nachvak gneiss. It is difficult to say at present whether they are differentiates of the anorthosite suite or whether they represent part of the country rock complex into which anorthosite intruded.

The structure of the anorthosite is characterized by a pervasive foliation or gneissosity, associated with flattening and recrystallization of original igneous textures. The unit is generally free, however, of the mylonitic foliations which characterize the surrounding granitoid gneisses. This is in large part probably due to its quartz-free nature and consequent resistance to ductile shearing.

The anorthosite predates granulite grade metamorphism and is intruded post-tectonically by late dykes. There is little doubt therefore that it is Archean. The timing of anorthosite intrusion with respect to the Nachvak gneiss is uncertain since original intrusive relationships have been obscured by migmatization of the anorthosite margins. If it is assumed that the inclusions of mafic granulite (metagabbro - leucogabbro) form part of the anorthosite suite then anorthosite must predate Nachvak gneiss. A corollary to this assumption is that the anorthosite is probably of similar age, possibly genetically related, to the metagabbroic component (type ii) of the early mafic gneisses.

Anorthosite intrusions have long been recognized as a characteristic feature of the Archean of West Greenland, *e.g.* the Fiskenaesset complex (Myers, 1975; Windley *et al.*, 1973)), where they were intruded in the period 3.3 to 2.8 Ga (Bridgwater *et al.*, 1976), and have recently also been recognized in the Nain Province (Collerson *et al.*, 1976; Wiener, 1981; Ermanovics *et al.*, 1982). The Churchill Province anorthosites represent the most extensive development of Archean anorthosite yet found in Labrador.

Tasiuyak Gneiss

This is a new term applied to the Nachvak Fiord sector of a 6-10 km wide belt of quartz+plagioclase+garnet gneiss recognized by Taylor (1979) as forming a major component of the eastern Churchill Province.

The unit is typically a leucocratic gneiss with an approximate average percent composition: quartz (40), plagioclase (20), garnet (30), biotite (10) + variable amounts of sillimanite, graphite and K-feldspar.

On washed surfaces the gneiss is highly distinctive, being finely banded with mauve, garnet rich, bands alternating on a 2-10 cm scale with white, quartz-plagioclase· bands containing scattered 1-3 cm garnet porphyroblasts. On weathered surface the gneiss is rusty brown, largely due to an iron-rich (pyrope rich?) garnet content, and appears similar to the nearby granulite facies Nachvak gneiss. Fine grained, red biotite is present in the garnet-rich melanocratic bands, often in association with prismatic sillimanite and graphite. Acicular sillimanite also occurs enclosed within garnet porphyroblasts. Orthopyroxene is suspected to occur in western exposures of the unit, but to date has not been confirmed in thin section. Quartz-rich bands, possibly of metaquartzite origin, and tonalitic bands are common in the more leucocratic gneiss components.

Compositional banding seen in the interior of the gneiss is isoclinally folded in shallow, north plunging folds with a strong, colinear quartz lineation and mylonitic axial planar fabric. Towards the eastern boundary of the gneiss the compositional banding is completely transposed into the mylonitic fabric and the unit becomes a fissile, flaggy gneiss with a thin compositional striping and an intense L>S (*cf.* Flinn, 1965) mylonitic fabric defined by ribbon quartz.

In thin section, textures are generally granoblastic polygonal, and little evidence is preserved of the intense grain size reduction suffered by the unit. Garnet does not appear markedly affected by mylonitization and appears to have recrystallized during deformation.

Pseudotachylyte veins from 10 cm to 3 m in width are present throughout the Tasiuyak gneiss. Veins are typically crowded with angular fragments of mylonite gneiss set in a black vitreous matrix, are discordant to mylonitic foliation, and clearly postdate the main period of cataclasis. Veins seen in the walls of Tasiuyak Arm have a general westerly dip and may be related to a late period of brittle reverse faulting or thrust movement. The eastern contact of the Tasiuyak gneiss is a 1 km wide zone of interleaving with the Nachvak gneiss, in which 1-50 m wide slices of white, mylonitic Tasiuyak gneiss are interleaved with similar size slices of brown, garnetiferous mylonitized Nachvak gneiss. The degree of interleaving decreases to the west; however, one small, 7 m wide, fault-bounded sliver of brown granulite gneiss was found in the center of the Tasiuyak gneiss north of Tasiuyak Arm. A small, 1 m wide, sliver of calc-silicate with the assemblage diopside + calcite + phlogophite + tremolite + plagioclase was found enclosed in Nachvak gneiss within the interslice zone east of Tallek Arm. It is uncertain whether this is derived from the Tasiuyak gneiss or is an original Nachvak gneiss inclusion.

At the west end of Nachvak Fiord, the gneiss is intruded by sheets of pale gray, garnet + orthopyroxene + diopside + plagioclase rock with granoblastic texture, corresponding in composition to leucogabbro. These are unlike other metagabbroic rocks in the area and their significance is, at present, uncertain. The western contact of the Tasiuyak gneiss was not seen during this season's work.

In previous work by Taylor (1979) and Morgan (1975), the Tasiuyak gneiss has been interpreted as a paragneiss formed by metamorphism of Aphebian sedimentary rocks. Given the mineral composition of the unit, this must be correct and it is difficult to propose any protolith other than an arenaceous clastic sediment. The gneiss, however, is remarkably uniform in composition and remarkably poor in potash for a typical metasedimentary gneiss. The compositional banding may have a primary origin but it more likely represents a metamorphic segregation fabric, possibly developed during intense partial melting, with the garnet-rich melanocratic bands representing refractory melanosome material. Ryan *et al.* (this volume), working on the southerly extension of this unit, have described localities where the gneiss has apparently intruded mafic granulite gneiss, suggesting that the unit was sufficiently mobile to act as a granitoid melt. This may account for the homogeneous nature of the gneiss. The low potash content of the gneiss may reflect an unusual protolith composition, *e.g.* a clastic rock derived from a tonalitic terrane; alternatively, it may be due to stripping of K^+ during intense anatexis.

The age of the Tasiuyak gneiss is also uncertain; the unit is suspected to have undergone granulite facies metamorphism, most likely during the 2.8 Ga Archean event, however, an Aphebian age cannot as yet be ruled out.

Granulite Gneisses West of Tasiuyak Gneiss

These were not examined during this season's work, but according to Taylor (1979), they represent a westerly continuation of the granulite granitoid gneisses (Nachvak gneiss of this paper).

Late Dykes

West of Ivitak Cove, the abundance of dykes decreases markedly, and no dykes have been found in the Tasiuyak gneiss. The few dykes that are present in the Nachvak gneiss and anorthosite have been partially to completely transposed into the Hudsonian regional fabric. Dykes are also generally thin (<1 m thick) and do not stand out on aerial photographs as they do in the other zones.

Some dykes retain a vestige of diabasic texture but most have been recrystallized to schists with the assemblage hornblende + ortho and clinopyroxene + plagioclase. Various stages of recrystallization have been recognized from those preserving primary pyroxene, to those in which primary pyroxene has recrystallized into lenticular grain aggregates or islands, to the final stage in which pyroxene, hornblende and plagioclase are intergrown in an equigranular granoblastic texture. Although the mineral assemblages are those of the granulite facies, it is felt that they reflect anhydrous recrystallization rather than very high grade metamorphism.

Post-tectonic Sills

Several sills were observed at about the 1000 m level on cliff faces of Idyutak Mountain and mountains south of Tasiuyak Arm. These could not be examined in outcrop but appear to be of mafic composition and entirely post-tectonic. In all probability, they are Helikian, belonging to either the *circa* 1.4 Ga Elsonian event, or the 1.2 Ga Gardar event.

TECTONIC DEVELOPMENT

The tectonic development of the Nachvak Fiord region is summarized in Figure 3. The earliest events are recorded in the mafic gneiss inclusions in the Nachvak gneiss. These inclusions may represent remnants of an early Archean terrane equivalent to the 3.3 - 2.8 Ga Upernavik supracrustals, and associated gabbroic intrusives, of the Saglek area, and to the Malene supracrustals of West Greenland. Anorthosite intrusion, probably as layered sheets, may also belong to this period.

The area was flooded by granodiorite-tonalite magma in a widespread plutonic event prior to 2.8 Ga, possibly equivalent to the Nuk event of West Greenland. Plutonism was followed by regional, granulite grade metamorphism associated with migmatization and deformation *circa* 2.8 Ga, and was succeeded by intrusion of the charnockitic Kammarsuit granite as part of a widespread, late Archean plutonic event. There then followed a period of late shearing and folding which appears to have increased in intensity to the west. Fold vergence indicates tectonic transport to the east. This event may also have been responsible for retrogression of the Archean granulites in eastern Nachvak Fiord, although this is probably also in part a Hudsonian effect. The full significance of the late Archean shearing is difficult to assess since much of it has been masked by Hudsonian deformation. It appears likely, however, that the event was at least partly responsible for the north-south linear grain and steep attitude of Archean structures in the Nachvak Fiord area. The late Archean shear zones also acted as structural inhomogeneites which localized Hudsonian shear zone deformation.

Late Archean shearing was followed by uplift, cooling and closure of the rock system to argon loss at around 2.5 - 2.4 Ga, based on the numerous K-Ar dates of this age from the northern Nain Province (Taylor, 1979). Following cratonization, the Archean crust was intruded by a basaltic dyke swarm which is a regional feature of both Labrador and Greenland and which probably heralded crustal rupture prior to development of lower Proterozoic mobile belts. The manner in which the dyke swarm reached a peak of intensity at the west end of Nachvak Fiord, and then suddenly died out, is intriguing but has no ready explanation.

Following an interval of subsidence on the margin of the developing Hudsonian Orogen, during which time the Ramah Group was deposited, the area was deformed again during the Hudsonian Orogeny *circa* 1.8 - 1.75 Ga. The marginal effects of this event are most clearly seen in the Ramah Group which was folded, cleaved and overthrust to the east. The basement underlying the Ramah Group lacks any Hudsonian structures other than brittle reverse fault zones and clearly did not undergo the shortening represented by folding and cleavage formation in the Ramah Group. The degree of deformation in the Ramah Group appears to have been at least partially accommodated by decollement along structures such as the Tinutyarvik thrust and the unnamed thrust at Rowsell Harbour. Deformation may also have resulted partly from transmission of stress across the Nachvak Fiord thrust, particularly if a large mass of basement was emplaced over the Ramah Group.

Within the remainder of the Churchill Border Zone Hudsonian deformation was concentrated in discrete shear zones which change in character from zones of brittle brecciation in the east to ductile shear in the west. Fold vergence within the zones indicates overthrusting to the east.

Hudsonian deformation in the Churchill Inner Zone is dominated by straightening and mylonitization in shear zones which increase in width and abundance towards the west, where they merge into a continuous mylonite zone in the Tasiuyak gneiss. From the behaviour of the late Archean dykes it is evident that the crust in the Churchill Inner Zone was considerably more ductile than in the border zone and that deformation occurred at high temperatures.

The most interesting feature of the zone, however, is the manner in which fold and lineation style changes from east to west into the Tasiuyak gneiss. In the Nachvak gneiss folds have 30 - 50° plunges to both north and south with vergance to the east. Lineation is not well developed, but where present it is usually an intersection lineation related to F_2 folds, and the fabric is S>L (Flinn, 1965). Within the interslice zone and the Tasiuyak gneiss, folds are upright, isoclinal and have a 10-15° northerly plunge colinear with an intense quartz lineation. The most probable origin for the lineation and mylonitic L>S fabric is a lateral simple shear environment, the most likely environment for which would be a major transcurrent fault zone. The colinearity of lineation and fold hinge lines is not unusual in a high shear strain environment and probably developed by progressive rotation of fold hinge lines into the lineation (*i.e.* the principal axis of the strain ellipsoid) at advanced strain states.

If the transcurrent model is correct, it indicates an abrupt change from an environment of vertical tectonics associated with overthrusting in the Churchill Border Zone, to lateral movements in the interior zone. Further work may show that this zone of lateral shear marks the edge of recognizable Archean crust in the Churchill Province. This would in turn lend considerable weight to the proposal by Bridgwater *et al.* (1973) that the eastern Churchill mylonites represent a major transcurrent shear zone boundary between Nain and Churchill plates.

Metamorphism associated with the Hudsonian Orogeny rises from greenschist facies in the Churchill Border Zone to amphibolite facies in the inner zone. The retrogression of Archean granulite assemblages seen in the eastern part of the border zone is in part a result of late Archean metamorphism but is also largely a Hudsonian feature, an assumption which is based on the similarity of alteration assemblages in the granulite gneisses and late dykes. The area of retrogression also corresponds fairly closely to the area occupied, or at one time probably occupied, by the Ramah Group, a unit which may have supplied the water necessary for hydrous alteration of the granulite assemblages. The remainder of the Churchill Border Zone and the inner zone were reworked under anhydrous conditions and presumably represent deeper crustal levels out of range of Ramah water. Metamorphic assemblages and textures in late dykes of the Churchill Inner Zone indicate that Hudsonian metamorphic grade rose to at least amphibolite facies but did not reach the stage of partial melting. Anhydrous recrystallization of granulite facies minerals occurred in this zone but may well have taken place at temperatures much lower than these normally associated with granulite grade metamorphism.

SUMMARY

As is usual with studies in areas of complex crustal history, as many problems have been raised as have been answered. The most significant aspect of the season's work is recognition of the extent to which Archean crust extends into the Churchill Province. This has ramifications for the geology north of Nachvak Fiord and suggests that much of the ground east of the quartz + feldspar + garnet mylonite (Tasiuyak gneiss) on Figure 1 may be reworked Archean crust, including all of the northern Labrador anorthosites. Also implicit is the suggestion that much of the granulite metamorphism in this area is of Archean rather than Hudsonian age.

Further work will be needed, however, to determine whether the Tasiuyak gneiss marks the western edge of Archean crust or if it is simply an intra-Archean feature. Related problems involve determination of the origins of the Tasiuyak gneiss and of the mylonite zone which it contains. Further work in 1983 will extend the cross-section examined in this study west to the Quebec border and may help to shed further light on these problems.

MINERALIZATION

Reported mineral occurrences in the area are limited to graphite in the Tasiuyak gneiss and pyrite in the Ramah Group (Douglas, 1976).

Graphite occurs as disseminated flakes on foliation surfaces and is usually concentrated in the more garnet rich bands of the gneiss.

Pyrite in the Ramah Group occurs within an approximately 0.5 m thick bed near the base of the Nullataktok Formation. The bed is composed of massive to bedded pyrite-pyrrhotite with pebbles of quartz, chert and shale (Knight and Morgan, 1981).

'Opal' has also been reported from the area (Douglas, 1976), but is in fact the ubiquitous blue quartz characteristic of the Kammarsuit granite and granulite facies gneisses.

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THE ARCHEAN-PROTEROZOIC BOUNDARY IN THE SAGLEK FIORD AREA, LABRADOR: REPORT 1[1]

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Abstract

The Aphebian Ramah Group in northern Labrador occupies the boundary zone between gneisses of the Archean (Kenoran deformed) Nain Province and gneisses of the lower Proterozoic (Hudsonian deformed) Churchill Province. The Nain Province displays few effects of lower Proterozoic thermotectonism, and the major lithological components identified by previous workers in the eastern Archean block are recognized throughout the area. The Ramah Group unconformably overlies the Archean complex; eastward transgression of the Hudsonian orogenic front has resulted in increased deformation and metamorphism of the Ramah southward from Saglek Fiord, and major thrust interleaving of basement and cover has occurred. Gneisses of the Churchill Province west of the Ramah Group are granulite facies rocks with mylonitic fabrics. Magnetite iron formation, graphite and copper sulphides occur in the area.

Introduction

The 1982 field season was the first of a two year project funded by the Federal Mineral Program in Newfoundland to examine the Nain-Churchill boundary zone in northern Labrador. The program involves 1:50 000 and 1:100 000 scale mapping of NTS sheets 14 L/2, 3, 4, 5, 6 and 7 (Fig. 41.1). The region lies within the southern part of the Torngat Mountains, where topography and exposure are ideal for documenting the character of the structural province boundary.

Ryan and Martineau were responsible for regional mapping. Associated participants Bridgwater and Schiøtte concentrated on specific problems in the Archean block arising from earlier mapping; Lewry examined part of the Ramah Group and its contact with adjacent gneisses.

Geological Setting

The survey area (Fig. 41.1) straddles the contact between the Nain Province in the east, an Archean block containing 3.6 Ga to 2.5 Ga gneisses and last deformed during the Kenoran Orogeny, and the Churchill Province in the west, an Aphebian mobile belt incorporating reworked Archean rocks and lower Proterozoic supracrustals last deformed during the Hudsonian Orogeny (Taylor, 1971). The Ramah Group, a variably deformed and metamorphosed Aphebian supracrustal sequence, occupies the central part of the map area, and records the easternmost influence of major Hudsonian thermotectonism.

Previous Work

The earliest geological studies in the region were those of Bell (1884), Daly (1902), Delebarre (1902), Coleman (1921) and Odell (1938). Geological mapping along the coastal strip was carried out by Christie (1952) and Douglas (1953). Major geological elements were defined only after regional scale mapping in the late 1960s and early 1970s (Taylor, 1969, 1970, 1971, 1979; Morgan, 1972, 1973, 1975).

In 1974 and 1975, a joint Geological Survey of Canada – Memorial University of Newfoundland party carried out detailed investigations of the geology of the eastern Archean block in the Saglek area (Bridgwater et al., 1975). This study defined and informally named major rock units, and established a relative age sequence of rocks and events involved in development of the complex. A concurrent Rb-Sr isotope study (Hurst et al., 1975) identified pre- 3.6 Ga components. It was established that the geological evolution of the Saglek area was similar to that of the Godthaabsfjord area of West Greenland (McGregor, 1973). Collerson and coworkers, between 1976 and 1978, continued detailed work on several aspects of the Archean complex of eastern Saglek Fiord, and further refined the chronology (cf. Collerson et al., 1976; Bridgwater and Collerson, 1976; Bridgwater et al., 1978; Collerson and Bridgwater, 1979; Kerr, 1980; Collerson et al., 1982).

Present Study

The current project involves geological mapping and economic mineral evaluation of the area west of that investigated in detail during the earlier GSC-MUN program, with particular emphasis on establishing the effects of the Hudsonian Orogeny on the Aphebian Ramah Group and its Archean basement along the eastern orogenic front. This report focuses on the Proterozoic rocks, and only salient features of Archean rocks not affected by penetrative Hudsonian deformation are documented here.

Nain Province

The Archean complex of the Nain Province comprises predominantly quartzofeldspathic gneisses, derived from intrusive protoliths interlayered with subordinate belts of supracrustal rocks derived from sedimentary and volcanic successions. The detailed work of Bridgwater et al. (1975) and by Collerson and his colleagues showed that the Archean block could be divided across the Handy fault into a largely amphibolite facies terrane in the east, and a largely granulite

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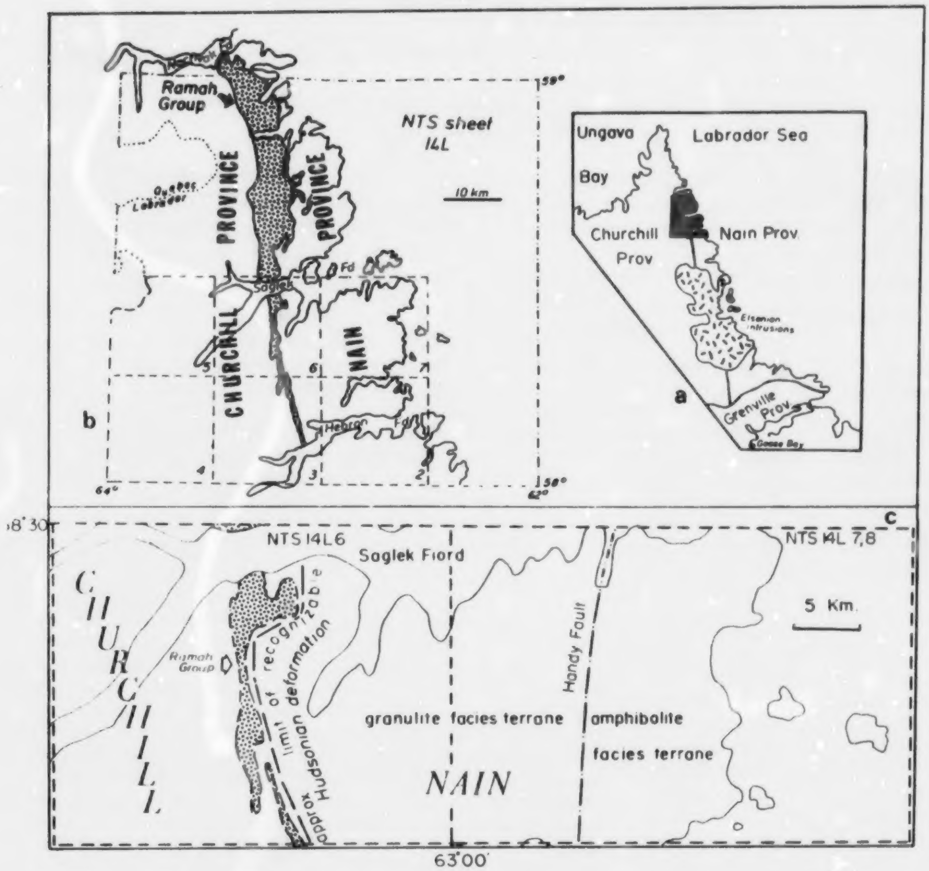

Figure 41.1

a. Sketch map showing the portion of Labrador covered by NTS sheet 14 L.

b. Outline of 14 L showing six 1:50 000 sheets to be covered during project.

c. Generalized subdivisions of regional geology in area of 1982 survey; in part after Bridgwater et al. (1975).

facies terrane in the west (Fig. 41.1, 41.2). Major rock units can be correlated on both sides of the fault, and the two terranes are interpreted to represent different structural levels of the same crustal components. Details of rock types are given by previous workers and only a generalized summary of chronology of the major stratigraphic units (Fig. 41.2) is presented here.

The earliest components are small (1-10 m^2 in area) rafts and belts (2 x 0.1 km) of basic intrusive and extrusive rocks, magnetite iron formation, calc-silicate rock and pelitic gneiss, known collectively as the Nulliak assemblage (Collerson and Bridgwater, 1979). These occur within a multiphase orthogneiss group (Uivak gneisses) comprising a grey migmatitic tonalitic to quartz monzonitic member (Uivak I) and a younger iron rich porphyritic (augen) granodioritic to dioritic member (Uivak II; Bridgwater et al., 1975). The Univak I suite was deformed and migmatized prior to the emplacment of the Uivak II augen gneiss. A major deformational and metamorphic/metasomatic event occurred circa 3.6 Ga which isotopically homogenized all rocks within the complex. This was followed by intrusion of a basic dyke swarm (Saglek dykes), and accumulation of a series of sedimentary, volcanic and basic intrusive rocks known as the Upernavik supracrustals (Bridgwater et al., 1975). Tectonic interleaving of the Uivak gneisses and Saglek dykes (Plate 41.1a) with the Upernavik supracrustals occurred circa 3.0 Ga giving rise to a regionally layered complex of paragneiss and orthogneiss. The complex was remobilized circa 2.8 Ga and the early orthogneisses were transformed into a heterogeneous suite ranging from Uivak gneiss with a local in situ irregular melt component, to lit-par-lit migmatites, to nebulites in which nearly all earlier features of the precursor are destroyed. The Upernavik supracrustal rocks were disrupted locally and injected by sheets of the mobilizate. Hurst et al. (1975) referred to these rocks as "undifferentiated gneisses". Recently Kerr (1980) and Collerson et al. (1982) have referred to this younger group of gneisses west of the Handy fault as the Kiyuktok gneisses. The reworking event appears to have been coeval with the granulite facies metamorphism, the effects of which have locally been nearly completely masked by later retrogression in the western block. Similar reworked gneisses in the southern part of the eastern (amphibolite facies) block, also showing evidence of having developed during a granulite grade event and having suffered subsequent retrogression, were earlier termed Iterungnek gneisses by Ryan (1977). These gneisses imply that rocks from deeper crustal levels are exposed to the south in the area east of the Handy fault.

In addition to the major lithostratigraphic units mentioned above, there are several types and generations of granitoid rocks.

The injection of regional diabase dyke swarms circa 2.3 Ga is the last major recognized event to affect the Archean complex prior to Aphebian erosion, uplift, and deposition of the Ramah Group. The dykes are conspicuous and abundant in the eastern half of the Nain Province in the study area, but become less abundant westward.

This year's mapping has shown that major rock units identified in the eastern Saglek Fiord area can be traced south and west within the Archean block (Fig. 41.2). Minor rafts and larger coherent belts of the Nulliak and Upernavik associations extend to the limits of the study area. One such belt of grey quartzite (interpreted as recrystallized chert),

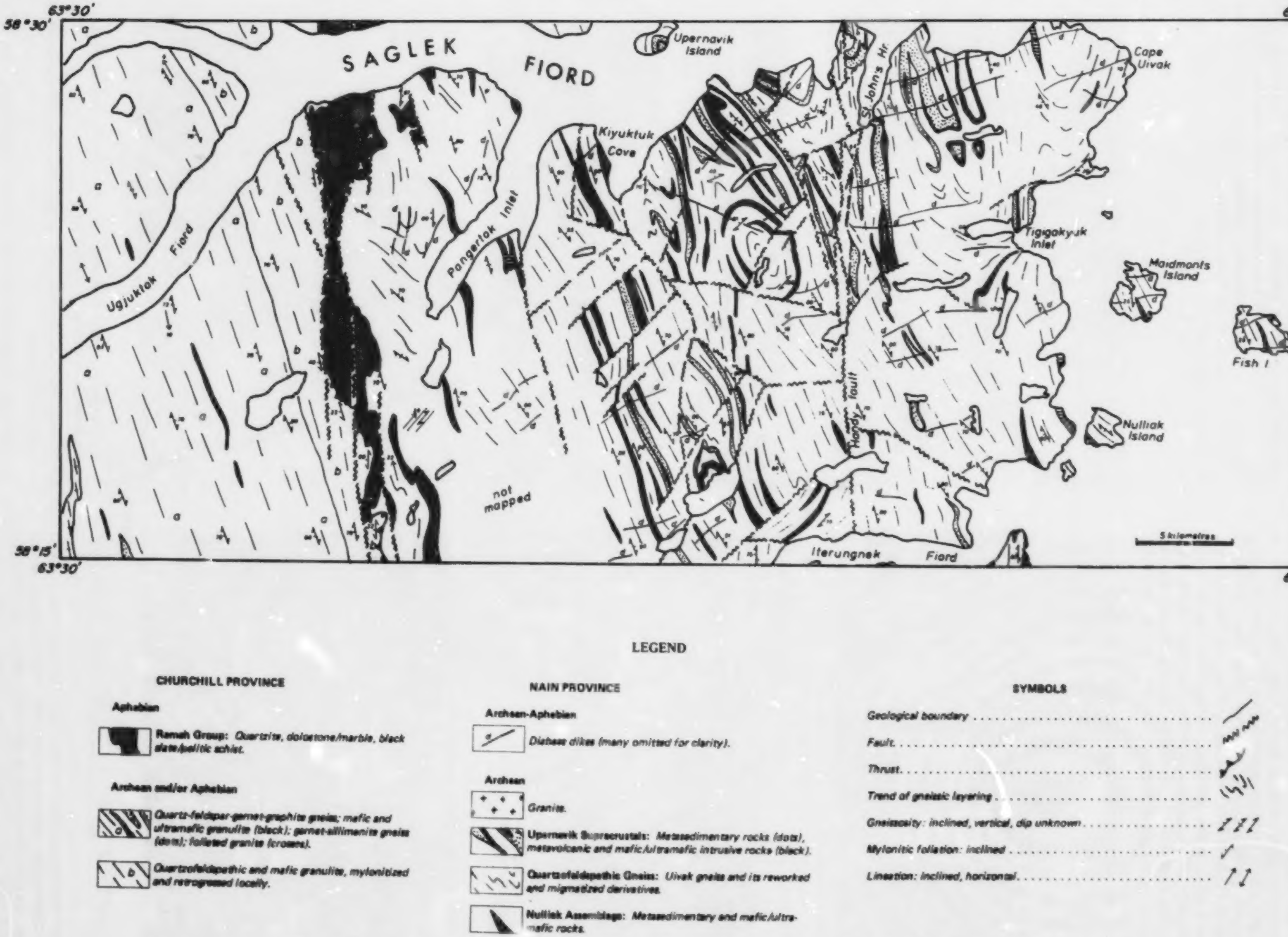
63°30'
58°30'
62°25'
58°30'
SAGLEK FIORD
Upernavik Island
Cape Uivak
St. John's Hr
Kiyuktuk Cove
Pangertok Inlet
Ugjuktok Fiord
Tigigakyuk Inlet
Maidmonts Island
Fish I
Nulliak Island
Handy fault
not mapped
Iterungnek Fiord
5 kilometres
58°15'
63°30'
58°15'
62°25'
LEGEND
CHURCHILL PROVINCE
Aphebian
Ramah Group: Quartzite, dolostone/marble, black slate/pelitic schist.
Archean and/or Aphebian
Quartz-feldspar-garnet-graphite gneiss; mafic and ultramafic granulite (black); garnet-sillimanite gneiss (dots); foliated granite (crosses).
Quartzofeldspathic and mafic granulite, mylonitized and retrogressed locally.
NAIN PROVINCE
Archean-Aphebian
Diabase dikes (many omitted for clarity).
Archean
Granite.
Upernavik Supracrustals: Metasedimentary rocks (dots), metavolcanic and mafic/ultramafic intrusive rocks (black).
Quartzofeldspathic Gneiss: Uivak gneiss and its reworked and migmatized derivatives.
Nulliak Assemblage: Metasedimentary and mafic/ultramafic rocks.
SYMBOLS
Geological boundary
Fault.
Thrust.
Trend of gneissic layering
Gneissosity: inclined, vertical, dip unknown
Mylonitic foliation: inclined
Lineation: inclined, horizontal.

Figure 41.2. Generalized lithological map for the area south of Saglek Fiord. The St. John's Harbour – Cape Uivak area and the coastal strip and off-shore islands between Tigigakyuk Inlet and Nulliak Island compiled from Collerson and Bridgwater (1979); area directly east of Kiyuktuk Cove after Kerr (1980).

magnetite iron formation and calc-silicate rock of the Nulliak assemblage at Pangertok Inlet is one of the largest pre-Uivak supracrustal remnants found in this area. The belt of migmatites east of St. John's Harbour (not distinguished on Fig. 41.2), originally defined by Bridgwater et al. (1975), is more extensive to the south, and the granitic component forms discrete homogeneous masses and sheets in this area. In addition, we have found that the gneisses east of the Handy fault especially in the Iterungnek Fiord area show more widespread effects of the 2.8 Ma granulite facies event than previously recognized. Retrogression caused by intrusion of younger granites has destroyed nearly all vestiges of this high grade overprint. Much of the western granulite facies block comprises Kiyuktok gneisses, but zones of unreworked granulite facies Uivak gneisses also occur, particularly in the south. This granulite terrane is characterized by conspicuous, white weathering, late kinematic granite sheets (generally less than 0.5 km wide) parallel to the regional lithological layering.

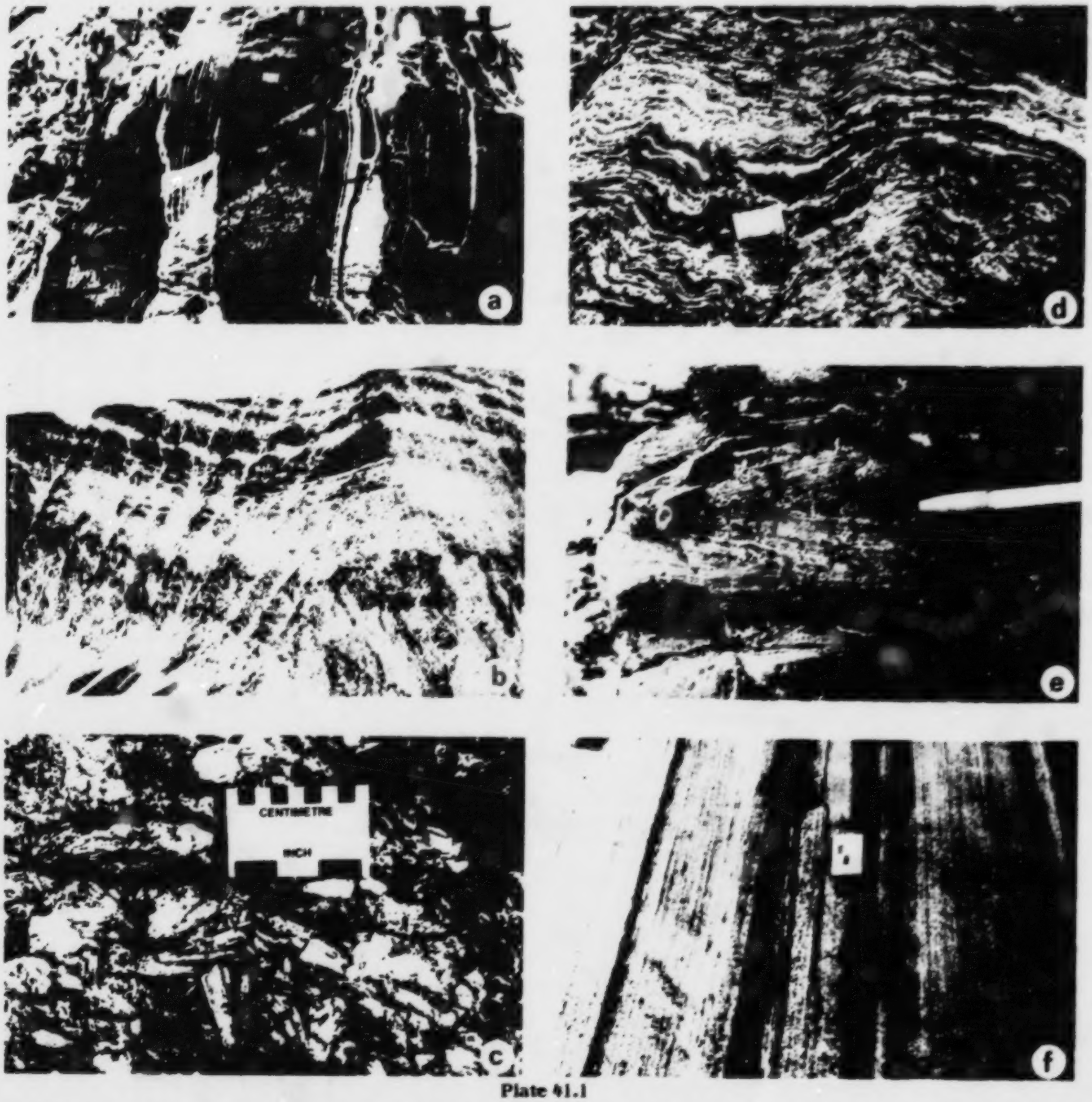

Plate 41.1

a. Migmatized Uivak gneiss and Saglek dykes, Maidmonts Island

b. Subhorizontal Ramah Group (Rowsell Harbour Formation) in unconformable contact with Archean gneiss, south shore of Saglek Fiord. Unconformity occurs at base of white quartzite unit in centre of photograph. Cliff face is approximately 300 m high

c. Radiating tremolite aggregates in marble, western margin of Ramah Group at Saglek Fiord

d. Refoliated gneiss adjacent to the Ramah Group, south of Pangertok Inlet

e. Isoclinal folds in Ramah Group quartzite, south of Pangertok Inlet

f. Quartz-feldspar-garnet-graphite gneiss, Ugjuktok Fiord.

Churchill Province

The Churchill Province is defined by the presence of rock types, isotopic ages, metamorphism, and structures resulting from the Hudsonian Orogeny. Its eastern boundary in northern Labrador was defined by Morgan (1975) as the eastern limit of the folded Aphebian Ramah Group. This definition is retained here, although present work indicates a Hudsonian thermotectonic overprint in the Archean foreland several kilometres east of the Ramah Group (Fig. 41.1c). Thus, in the study area, the Churchill Province comprises the Ramah Group, bounded to the west by granulite facies quartzofeldspathic gneiss and quartz-feldspar-garnet-graphite gneiss. The Ramah Group is affected by increasing deformation to the south and west; the western gneisses are typified by a north- to northwest-trending mylonitic fabric.

Hudsonian Effects in the Archean Foreland

Many faults and shear zones in the Archean block, including the Handy fault may in part be related to Hudsonian deformation (cf. Bridgwater et al., 1975). More obvious, however, are the effects which the Hudsonian tectonic overprint has had on the basement up to several kilometres east of the Ramah Group. The best markers of this are the late Archean diabase dykes which are converted into massive or foliated amphibolite near the more pronounced deformational front defined by the Ramah Group. In the vicinity of the latter south of Pangertok Inlet, both dykes and planar features in the basement gneisses are commonly rotated into parallelism with the sheared basement-cover contact. The extent of Hudsonian meta-morphic overprint on the structurally unreworked Archean gneisses where dykes are absent is ill-defined but much of the retrogression in the terrane immediately east of the Ramah Group may be of Proterozoic age.

Hudsonian effects on the Ramah Group

The Aphebian Ramah Group (Morgan, 1972, 1973, 1975; Knight, 1973) is best preserved north of Saglek Fiord, in a northerly-trending, doubly plunging synclinal belt up to 16 km wide, extending approximately 90 km from Saglek Fiord to Nachvak Fiord (Fig. 41.1b). Six formations are recognized in the Group (Knight and Morgan, 1977, 1981; Table 41.1). In this region the eastern boundary of the fold belt is little disturbed, and the group rests with profound unconformity on peneplaned Archean gneisses. The western boundary is faulted and overthrust, and metamorphic grade reaches amphibolite facies. Morgan (1975) recognized that the Ramah Group extended south of Saglek Fiord through the present study area as a narrower, increasingly tectonized and metamorphosed belt; he was able to trace it 35 km southward to Hebron.

In the north of the study area, along the south shore of Saglek Fiord (Fig. 41.3), the group comprises interbedded white and maroon quartzite, pelite and dolostone of the Rowsell Harbour and Reddick Bight formations, overlain by black slate of the Nullataktok Formation. Several diabase sills are present, one of which, in the Nullataktok Formation, is the highest stratigraphic unit preserved. The sequence is folded into open anticlines and tighter synclines. In the east it is autochthonous and lies unconformably on basement (Plate 41.1b). In the west it is fault-bounded and is in sheared contact with underlying Archean gneiss. Vertical and lateral changes in metamorphic grade are apparent along the fiord wall. Pelite of the Nullataktok Formation is represented by black slate at 600 m elevation, whereas pelite of the Rowsell Harbour Formation at sea level is muscovite-andalusite schist containing kyanite in quartz-feldspar segregations. Similarly, brown dolostone interbedded with quartzite at the top of the Reddick Bight Formation in the east is transformed to spectacular pale green tremolite marble in the west (Plate 41.1c).

Table 41.1

Summary of stratigraphy of the Ramah Group (from Knight and Morgan, 1981)

RAMAH GROUP Maximum measured thickness 1702 m	Cameron Brook Formation		200 m +	Greywacke – sandstones and mudstones.
	Typhoon Peak Formation		85-130 m	Slates; some sandstone and limestone.
	Warspite Formation		165 m	Dolomitic breccias and sandstones; dololutites; some limestone and calcareous mudstone; argillite, mudstone.
	Nullataktok Formation		595 m	Varicoloured mudstones and shales; graphitic pyritiferous; chert; pyrrhotite-pyrite unit; calcareous and dolomitic mudstones.
	Reddick Bight Formation		53-143 m	Black quartzite; grey muddy sandstone; sandstone-siltstone laminites; yellow weathering dolomite unit.
	Rowsell Harbour Formation 251-470 m	Upper White Quartzite Member	46-267 m	White quartzite; some conglomerate; interbedded shale and mudstone.
		Phyllite Member	15-44 m	Laminated purple mudstone and very fine grained sandstone.
		Purple Quartzite and Mudstone Member	75-157 m	Pink quartzite; alternating units of purple quartzite and purple mudstone; grey sandstone and shale.
		Volcanic Member	0-9 m	Altered tholeiitic basalt flow.
		Lower White Quartzite Member	31-97 m	Granitic wash; pebble conglomerate; white quartzite with heavy mineral laminae; white quartzite; pebbly, coarse grained sandstone.

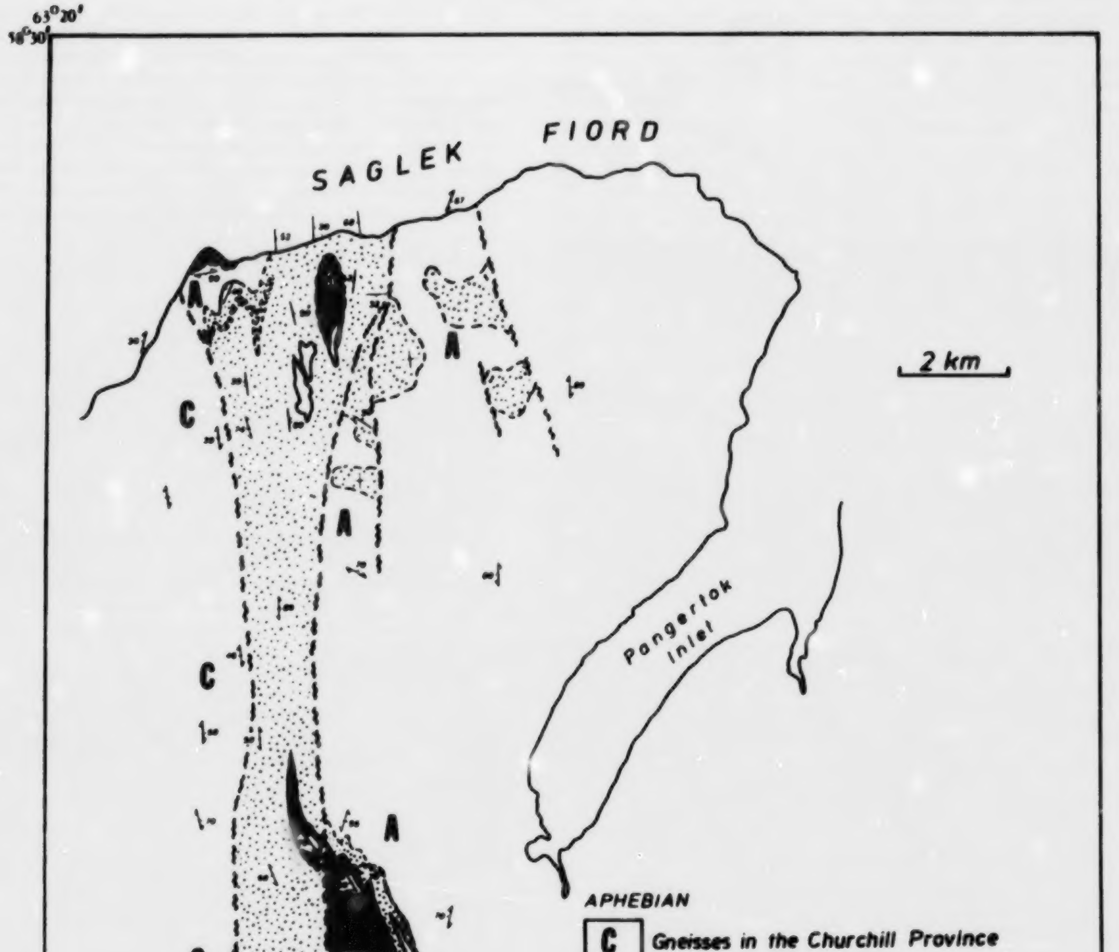
63°20'
58°30'
SAGLEK FIORD
2 km
Pangertok Inlet
C
A
APHEBIAN
C Gneisses in the Churchill Province
RAMAH GROUP Undivided quartzite, pelite, and dolostone of Rowsell Hr. and Reddick Bight Formations (dots); pelite of Nullataktok Fm. (black); diabase sills (random lines)
ARCHEAN
A Gneisses in the Nain Province, refoliated during Hudsonian Orogeny adjacent to Ramah Group south of Pangertok Inlet; stripe pattern = mafic units
Geological boundary (defined, approximate, assumed)
Fault (approximate)
Thrust (approx.)
Bedding (horizontal; inclined; tops known, unknown)
Schistosity, mylonitic foliation
Gneissic layering
58°15'
63°00'

Figure 41.3. Distribution of the Ramah Group in the map-area south of Saglek Fiord.

Southward from Saglek Fiord, the Ramah Group narrows markedly in outcrop width, becomes entirely bounded by tectonic junctions, and is increasingly tightly folded and metamorphosed. Approximately 10 km south of the fiord it splits into two or more narrow belts, generally less than 1 km in width. Just north of this bifurcation, an extensive zone of black muscovite schist is thought to represent Nullataktok Formation; the quartzite sequence to the east is tectonically thinned, and the eastern contact is a décollement surface of basement-cover detachment. The western margin in this part of the belt varies from a steep reverse fault to a low angle westward-dipping thrust which has transported refoliated granulite facies gneisses over the Ramah Group.

Still farther south, the narrow belts of Ramah Group are entirely of white quartzite, muscovite schist and minor calc-silicate rocks (Rowsell Harbour Formation?). The configuration of the belts is a function both of thrust interleaving with basement and multiple folding. All contacts are tectonic; on both margins of the belts, recognizable Ramah Group is separated from basement gneisses by a zone of tectonic schist, phyllonite, and mylonite derived both from cover and basement (Plate 41.1d). Structural data indicate that early deformation involved thrust slice intercalation of mylonitically refoliated basement coeval with development of recumbent isoclinal folding and axial planar schistosity within the cover (Plate 41.1e). Both F_1 folds and basement slices are refolded by open to tight upright F_2 folds, and S_1 axial plane fabrics are crenulated. Further, post-F_2, thrusting is evident along the southern periphery of the area where a subhorizontal sheet of quartzofeldspathic and mafic gneiss overrides and truncates upright F_2 folds in the Ramah Group.

Gneisses of the Churchill Province

The zone immediately west of the Ramah Group comprises dark green to grey weathering, slightly retrogressed granulite facies quartzofeldspathic and subordinate mafic gneisses. These rocks commonly possess a mylonitic fabric, and pseudotachylyte vein networks related to later faulting occur locally. It is unclear at present whether the granulite facies parageneses are Archean or Proterozoic in age. Morgan (1975) interpreted numerous discordant amphibolites in this unit north of Saglek Fiord as metamorphic equivalents of the late Archean dykes east of the Ramah Group. If this is so, then the character of the gneisses probably results from an Archean granulite event, overprinted by a Hudsonian amphibolite facies metamorphism.

The westernmost part of the map area comprises a rather uniform, white weathering, quartz-feldspar-garnet-graphite gneiss (Plate 41.1f) of uncertain derivation. Mesoscopically the gneiss has an apparently medium grained granitoid texture, with local coarse pegmatoid zones; however, mineral subdomains are polycrystalline and the rock in fact has a blastomylonitic fabric. Locally, lenticular grey quartz subdomains parallelling this fabric are slightly oblique to the compositional layering. A pronounced mineral rodding plunging gently (2-10°) north and south is evident throughout the unit. Two phases of garnet growth, predating and postdating the main tectonic fabric, are evident.

The contact of the white granitoid gneiss with granulite gneisses to the east is largely modified by faulting, but locally the contact is marked by a zone in which thin (1 m or less) sheets of the quartz-feldspar-garnet-graphite gneiss occur within the granulites with an apparently intrusive relationship. Subordinate metasedimentary and mafic granulite rafts occurring locally within the granitoid gneiss also display small-scale intrusion by white granitoid neosome.

Morgan (1975) interpreted the western leucocratic granitoid gneiss as paragneiss. However, the inclusion of discrete paleosomal metasedimentary rafts, contact relations with the granulite gneisses to the east, rather uniform character over large areas, and apparent coarse grained premylonitic relict granitoid textures suggest that this unit is predominantly magmatic in origin. Mineralogically it resembles granitoid segregations and intrusive bodies found in granulite facies paragneisses in the Archean block to the east. It is, therefore, suggested that this unit is a diatexite representing an advanced stage of anatexis of metasediments under granulite facies conditions. However, the age of the metasedimentary paleosome and extent of migration of the mobile mass is unknown.

Economic Geology

The Archean layered quartzite-magnetite iron formation documented by exploration companies in the 1950s and 1960s (Brinex, 1960; Schlobohm, 1958) has a limited distribution. The best zones are found on the southeast shore of Pangertok Inlet on Saglek Fiord where a belt of calc-silicate rocks and grey quartzite (recrystallized chert?) of the Nulliak assemblage locally contains 1-3 m bands of quartzite with 70-80 per cent magnetite. Several other iron formations occur in this area, but none appear economically viable.

A graphite occurrence described from the white granitoid gneiss of inner Saglek Fiord by H.S. MacLean (in Douglas, 1953) could not be located. However, coarse graphite, with a similar mode of occurrence to that described from the prospect, has been observed by us in this part of the survey area.

A scintillometer ("total count" BGS-1L) survey proved unrewarding, with 4000 cps from gneisses at Pangertok Inlet being the highest reading recorded. This is only 8-10 times normal background for this area.

Minor sulphide mineralization occurs on the south wall of Saglek Fiord, where a gabbro sill has intruded black slate of the Nullataktok Formation of the Ramah Group. The slate locally contains 2-5 per cent disseminated pyrite, pyrrhotite and chalcopyrite. A scintillometer survey of the Ramah/basement contact did not reveal any anomalous radioactivity.

Summary

The major Archean rock units identified by earlier mapping in the Nain Province of the Saglek area have been traced southward and westward. The Hudsonian front swings eastward south of Saglek Fiord, transgressing the Ramah Group and giving rise to a complex zone of southward-increasing deformation and metamorphism, but the extent of Hudsonian overprint on the Archean terrane of the Nain Province has not been fully defined. The area has several small mineral occurrences.

Acknowledgments

The assistance of Dan Lee, Bob Voutier, Tim Froude and Janet Russell contributed to the success of the field season. Helicopter services were provided by Codiac Helicopters of Moncton, New Brunswick. The staff of Petro-Canada Ltd. at Saglek and St. John's are thanked for continued co-operation throughout the summer.' The Tuttles in Goose Bay expedited, and provided logistical support. This paper was improved by critical review by C. Gower, P. Erdmer, and R. Wardle.

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GEOLOGY OF THE WINOKAPAU LAKE AREA, GRENVILLE PROVINCE, CENTRAL LABRADOR[1]

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Also in Current Research, Part A, Geological Survey of Canada, Paper 83-1A, p. 305-312, 1983.

Abstract

Precambrian crystalline rocks within the northern part of the Grenville Structural Province southeast of Churchill Falls, Labrador, constitute a mixed granitoid-gneiss terrane. A range of hills is underlain by granulite facies quartzofeldspathic paragneiss containing the mineral assemblage hypersthene, sillimanite, quartz and feldspar. Lowlands contain amphibolite facies quartzofeldspathic paragneiss, orthogneiss and deformed porphyritic granite characterized by the assemblage biotite, sillimanite, muscovite, garnet, quartz and feldspar.

Although extensively tectonized during the Grenvillian Orogeny, paragneiss within the area is tentatively correlated with equivalent rocks in and around the Red Wine Mountains massif to the north which have been deformed and metamorphosed during the Paleohelikian sub-era. Orthogneiss is correlated with granitoid rocks of known Paleohelikian age. The protolith of both amphibolite and granulite grade paragneiss may be as old as Aphebian, and probably had its origin in eugeosynclinal facies greywackes and pelitic sandstones of the Hudsonian orogen in western Labrador.

Introduction

Geological studies in Labrador have to date been focused mainly on Aphebian to Paleohelikian sedimentary-volcanic successions of the Labrador Trough and the Central Mineral Belt. By comparison, relatively little has been done on the huge expanse of gneissic and granitoid rocks belonging to the Grenville Structural Province in southern Labrador. This is due to several factors such as lack of exposure, geological complexity, difficulty in access and the resultant logistical problems which arise such as increased cost of field operations. Most previous programs in the Grenville Province have been large scale, regional geological reconnaissance surveys carried out by the Geological Survey of Canada (Eade, 1952, 1962; Wynne-Edwards, 1960; Stevenson, 1967a, b, 1968, 1969, 1970; Jackson, 1974) at 1:500 000, 1:250 000 or 1:125 000 scale. In addition, Brinex has carried out mapping in selected areas of the Grenville Province ranging in scale up to 1:250 000.

In 1978, with the aid of a Federal-Provincial funding agreement to help offset the high cost of field work, the Newfoundland Department of Mines and Energy began a systematic approach aimed at mapping at 1:100 000 scale, a strip at least 2 NTS map sheets deep along the entire Grenville Front Zone from the Labrador Trough in the west to the coast in the east. In central Labrador, this was done originally with the idea of following previously mapped units, some of which had either proven or potential mineralization, from the Central Mineral Belt, south into the Grenville Province in order to define more clearly the nature of the Grenville Front Zone in this part of Canada. The area mapped between 1978 and 1981 is shown in Figure 42.1. Summaries of this work can be found in Thomas and Hibbs (1980), Thomas (1980, 1981), Thomas et al. (1981) and Jackson and Finn (1982). The study of Emslie et al. (1978) was initiated prior to that of the Newfoundland Department of Mines and Energy, and data from this study have since been incorporated.

In 1982 it was decided to extend the mapping southwestward into the Grenville Province (Fig. 42.1) due to some interesting results from the 1978-1981 study. Specifically, it was discovered that gneissic rocks thought originally to have been Grenvillian in age, were older; Rb-Sr isochron ages of

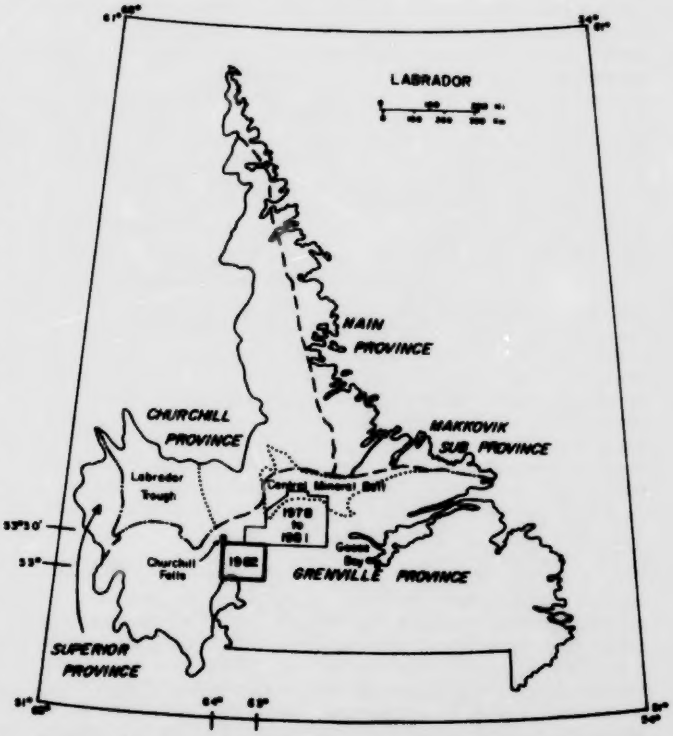

Figure 42.1. Location of present and previous map areas in central Labrador (structural province divisions after Taylor, 1971).

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[1] Contribution to Canada-Newfoundland co-operative mineral program 1982-84. Project carried by Geological Survey of Canada and Newfoundland Department of Mines and Energy.

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1660 ± 37, 1661 ± 88 and 1666 ± 28 Ma were obtained by Fryer (in Thomas, 1981, and personal communication, 1982). This prompted a renewed search for polydeformed gneisses which would yield Grenvillian ages. The 1982 map area is located southeast of Churchill Falls and encompasses NTS 1:50 000 sheets 13E/3, 4, 5 and 6 (Fig. 42.1). Access is primarily by helicopter from Churchill Falls or by road from the Trans-Labrador Highway.

Regional Setting

Regional metamorphic grades and structural trends of rocks in Labrador are shown in Figures 42.2 and 42.3 respectively. The boundaries of the five structural provinces in Labrador (after Taylor, 1971) appear on Figure 42.1 along with those of the Labrador Trough and Central Mineral Belt. The dashed line representing the limit of the Grenville Province indicates the approximate northern extent of recognizable Grenvillian structural deformation. This does not preclude the presence south of this line of rocks exhibiting evidence of older orogenic events.

The Winokapau Lake area encompasses a mixed granitoid, paragneiss terrane metamorphosed primarily to amphibolite and granulite facies (Fig. 42.2). It is located along the southwestern edge of a larger block of crystalline rocks to the east and northeast, the Red Wine Mountains massif, consisting mainly of amphibolite and granulite grade paragneiss intruded by a suite of noritic and charnockitic rocks (see Emslie et al., 1978; Thomas et al., 1981). This block has been thrust northwards over a body of deformed granitoids (termed North Pole Brook Intrusive Suite by Thomas and Hibbs, 1980) of Paleohelikian age. These granitoids are in turn thrust over subgreenschist to greenschist grade sedimentary and volcanic supracrustal rocks belonging to the Nelhelikian Seal Lake Group. To the north of the Winokapau Lake area, a boggy lowland terrane contains scattered exposures of North Pole Brook Suite granitoid rocks and older paragneiss. West of the area, the granitoid gneiss terrane continues into the region presently being investigated by Nunn and Christopher (1983). With the exception of granitoids belonging to the North Pole Brook Intrusive Suite, rocks in the region are polydeformed and polymetamorphosed. The entire area has been affected to some degree by the Grenvillian Orogeny, but abundant evidence exists, especially in granitoids and gneiss to the north, of an earlier, presumably late Hudsonian, orogenic event (Thomas, 1981).

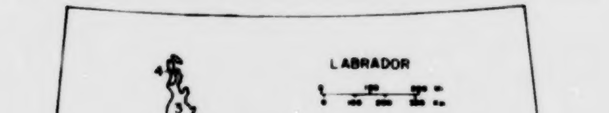


Figure 42.2. Regional metamorphic grades of rocks in Labrador (modified from Fraser and Heywood, 1978).

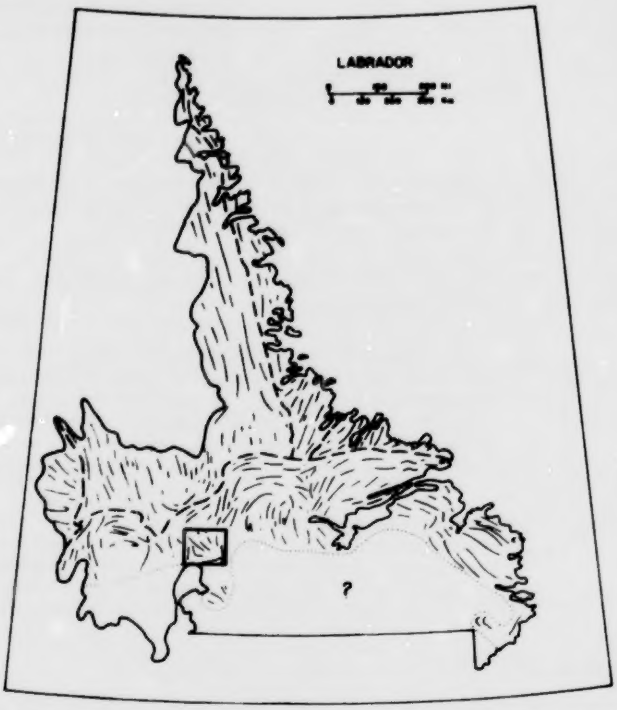


Figure 42.3. Generalized map illustrating regional structural trends in Labrador.

General Geology of the Winokapau Lake Area

Although structurally and metamorphically complex, there is little lithological variation of rocks within the map area. Eight units were defined (Fig. 42.4), with two of them, quartzofeldspathic paragneiss and granodioritic to granitic orthogneiss, constituting approximately 80 per cent of exposed bedrock. A range of hills in the northeastern and southern segments of the area is underlain by granulite grade paragneiss (unit 1a), tentatively correlated with the Hope Lake gneiss of Emslie et al. (1978), Thomas (1981) and Thomas et al. (1981). The northeastern hills are actually a physical extension of the Red Wine Mountains massif in which granulite grade paragneiss was first recognized by Emslie et al. (1978). Till or sand covered lowland terrane in the northern, south-central and southeastern parts of the area is dominated by poorly exposed amphibolite grade paragneiss (unit 1b), similar in lithological character and style of deformation to Disappointment Lake gneiss of Thomas (1981) and Thomas et al. (1981) to the northeast. Although granulite and amphibolite grade paragneisses in the vicinity of Winokapau Lake are mineralogically distinct from one another, they exhibit lithological and compositional similarities. It is, therefore, presently assumed that the two are metamorphic variants of the same unit.

Orthogneiss (unit 4b) is poorly to moderately well exposed, primarily in a 16 km wide band passing diagonally from northwest to southeast, through the central part of the area. Porphyritic granite to granodiorite protolith (unit 4a) is identifiable in places within this band. A small body of orthogneiss is also exposed near the northeastern corner of the area. Granodiorite to quartz diorite (unit 5), recrystallized and foliated but with a recognizable relict igneous texture, occurs in the north-central part of the area. It is correlated with less deformed granodiorite to the north, belonging to the North Pole Brook Intrusive Suite of Thomas (1981) and Thomas et al. (1981). Three small, recrystallized and foliated quartz dioritic to dioritic bodies (unit 6) of unknown age and origin are present within the gneisses south of the Churchill River. In addition, a small, plutonic body of foliated to massive granite (unit 8) occurs just south of Winokapau Lake in the southeastern part of the area. Its predominantly massive nature suggests that the body is a late syn- to post-kinematic intrusion associated with the Grenvillian Orogeny.

Gabbronorite, gabbro, diabase and parts of a charnockitic suite more widely exposed to the northeast of the map area (see Emslie et al., 1978), constitute the remaining lithologies. Folded bodies of norite (unit 2) are confined to granulite grade paragneiss in the southern hills. Paleohelikian Shabogamo gabbro and gabbronorite (unit 7) occur as deformed sills and bodies within the amphibolite grade paragneiss and orthogneiss; two late syntectonic diabase dykes of unknown affinity cut orthogneiss and paragneiss near the eastern boundary of the area. The charnockitic rocks (unit 3) are minor in occurrence, confined to several small outcrops north of the west end of Winokapau Lake and in the central part of the southern granulite paragneiss.

All rocks within the Winokapau Lake area have been extensively deformed during the Grenvillian Orogeny; but at least some of the earlier folds and possibly faults are probably pre-Grenvillian. No radiometric age data are presently available on rocks of the Winokapau Lake area, but geological relationships between units and tentative correlations with less tectonized equivalent rocks to the north and northeast, suggest a Paleohelikian or earlier age protolith for the gneisses. They most probably originated within a eugeosynclinal succession of greywackes, sandstones and mudstones similar to that exposed along the western margin of the Labrador Trough.

Paragneiss (unit 1)

Granulite grade paragneiss (unit 1a) is rusty pink to buff, fine- to medium-grained, dense and extremely resistant to weathering. It is banded, with prismatic to fibrous sillimanite, fine grained hypersthene, magnetite and minor biotite confined to mafic layers which pinch and swell, imparting an anastomosed appearance to the rock. Mafic bands vary in width up to 2 cm and commonly contain lenticular clots of densely packed aggregates of fibrolitic sillimanite, pyroxene and magnetite. Ubiquitous fine grained magnetite within these bands results in the granulite paragneiss having a unique, intense aeromagnetic "signature". The anomaly patterns reflect bedrock structural trends and can be used to delineate the limits of the gneiss in drift covered areas. Felsic bands consist of very dense, fine- to medium-grained granoblastic polygonal aggregates of quartz, K-feldspar and plagioclase. These bands are tightly folded, also pinch and swell, and may be up to 5 cm wide. Black pseudotachylyte lenticles and discontinuous layers up to 1 cm wide are commonly found parallel or subparallel to mafic bands; pseudotachylyte veinlets in the same size range also crosscut felsic bands. Abundant evidence of partial melting is present in the granulite paragneiss. Both layer parallel and crosscutting quartz-feldspar sweats are common, as are localized zones of incipient melting within felsic bands. This melting took place under dry conditions at high temperatures as evidenced by subhedral to euhedral hypersthene crystals up to 1 cm long within some of the sweats.

Granulite grade paragneiss is highly deformed with tight isoclinal, chevron and hook folds well developed on a centimetre scale. Shear and cataclastic zones occur locally near faults and along the contact with amphibolite grade paragneiss in the lowlands. The polydeformed nature, high metamorphic grade and predominance of a quartz, feldspar, sillimanite assemblage suggest that granulite paragneiss is derived from an old sedimentary protolith.

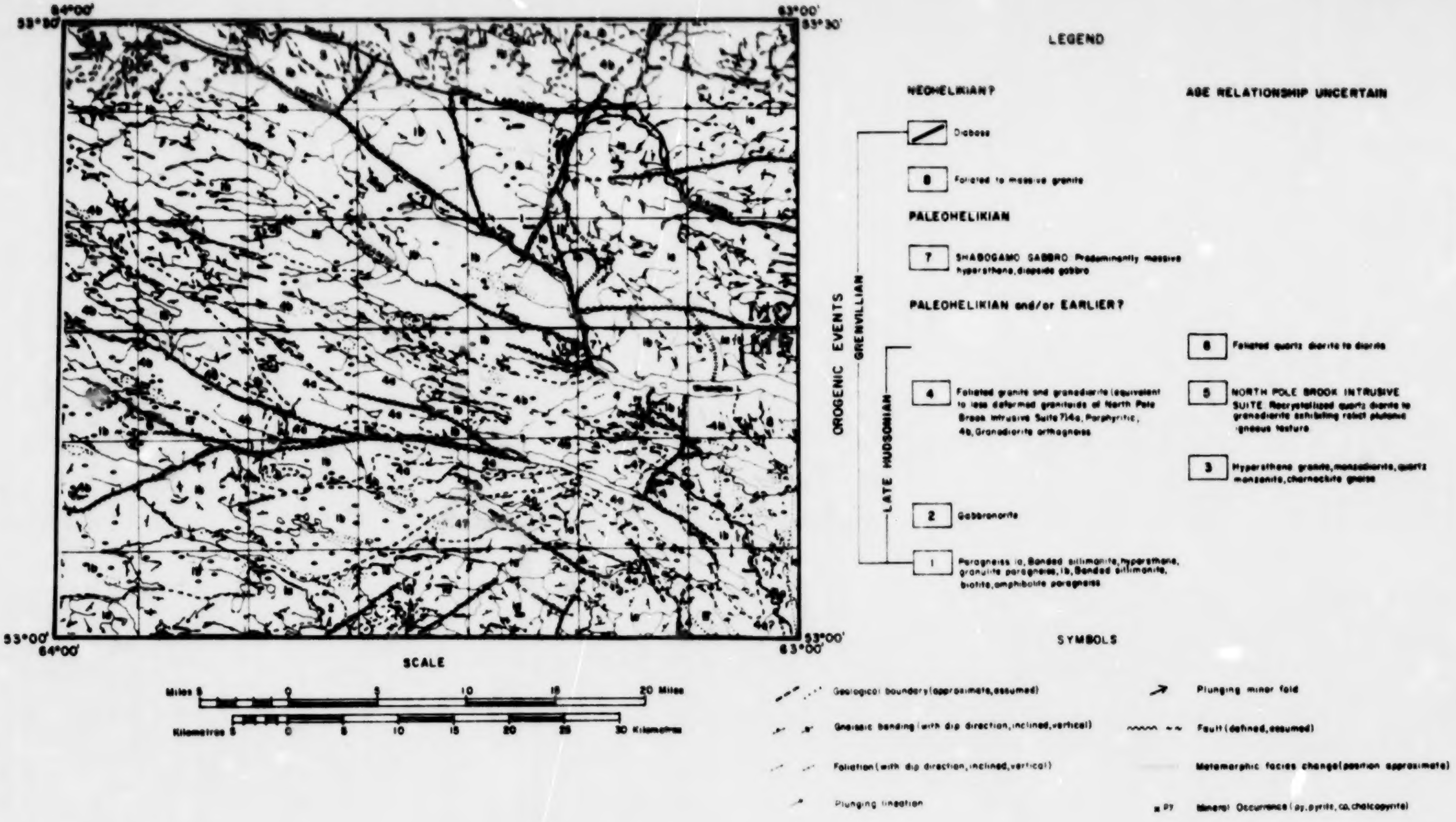
Buff-white to pink, amphibolite grade paragneiss (unit 1b) is similar in lithology to granulite grade paragneiss, consisting of quartz, K-feldspar, plagioclase, sillimanite, biotite, muscovite, garnet and magnetite-ilmenite. Hornblende is present in local amphibolite layers within the quartzofeldspathic gneiss and metamorphic differentiation is well developed with mafic minerals segregated into bands up to 0.5 cm wide, separated by 2-3 cm wide quartz-feldspar bands.

Unlike granulite grade paragneiss, amphibolite paragneiss is less dense and more fissile due to its richness in biotite and muscovite. Strong linear and planar fabrics are developed respectively within and parallel or subparallel to the gneissic banding. Sillimanite may be prismatic or fibrolitic and tends to form radiating clusters along the contact between mafic and quartzofeldspathic bands. Lenticular fibrolite clots are also common within the mafic bands as are euhedral to subhedral garnet porphyroblasts which overgrow the foliation. Granoblastic polygonal texture predominates within the quartz-feldspar bands and is in most places medium- to coarse-grained. At least three generations of pegmatite sweats indicate that partial melting was an ongoing process during formation of the paragneiss. Early melt bands, parallel to the gneissic banding, are abundant throughout the amphibolite paragneiss terrane and commonly result in a migmatitic structure. These bands are ptygmatically folded and cut by a later set of veinlets which are also deformed. The most recent sweats are associated with deformed, coarse grained tourmaline pegmatite dykes; together with these dykes, they crosscut all previous structures, melt bands and veinlets.

Amphibolite grade paragneiss is highly tectonized, exhibiting complex minor fold patterns including mushroom and dome and basin structures. The structural style, mineralogy and overall lithology of this unit compares favourably with that of the Disappointment Lake gneiss of Thomas (1981) dated by B. Fryer (personal communication, 1982) by Rb-Sr at 1666 ± 88 Ma. Although amphibolite grade paragneiss around Winokapau Lake has undergone a more complex deformational history, it is tentatively correlated with Disappointment Lake gneiss to the northeast.

Gabbronorite (unit 2)

Bodies of noritic to gabbroic composition intrude granulite grade paragneiss in the south. They consist of plagioclase, hypersthene, diopside, magnetite, and minor biotite and hornblende. Igneous textures are preserved in the centres of the bodies whereas the margins are recrystallized to granoblastic polygonal aggregates. Sharp, intrusive, chilled marginal contacts of gabbronorite against granulite gneiss are well exposed. These rocks are similar in composition and intrusive style to gabbronoritic rocks to the northeast, described by Emslie et al. (1978) and Thomas et al. (1981).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LEGEND
NEOHELIKIAN?
Diabase
8 Foliated to massive granite
PALEOHELIKIAN
7 SHABOGAMO GABBRO Predominantly massive hypersthene, diopside gabbro
PALEOHELIKIAN and/or EARLIER?
4 Foliated granite and granodiorite (equivalent to less deformed granitoids of North Pole Brook Intrusive Suite?) 4a, Porphyritic, 4b, Granodiorite orthogneiss
2 Gabbronorite
1 Paragneiss 1a, Banded sillimanite, hypersthene, granulite paragneiss, 1b, Banded sillimanite, biotite, amphibolite paragneiss
AGE RELATIONSHIP UNCERTAIN
6 Foliated quartz diorite to diorite
5 NORTH POLE BROOK INTRUSIVE SUITE Recrystallized quartz diorite to granodiorite exhibiting relict plutonic igneous texture
3 Hypersthene granite, monzodiorite, quartz monzonite, charnockitic gneiss
OROGENIC EVENTS
GRENVILLIAN
LATE HUDSONIAN
SYMBOLS
Geological boundary (approximate, assumed)
Gneissic banding (with dip direction, inclined, vertical)
Foliation (with dip direction, inclined, vertical)
Plunging lineation
Plunging minor fold
Fault (defined, assumed)
Metamorphic facies change (position approximate)
Py Mineral Occurrence (py, pyrite, cp, chalcopyrite)

Figure 42.4. *Geology of the Winokapau Lake area, central Labrador.*

Hypersthene Granitoids (unit 3)

Several outcrops define a small body of hypersthene-bearing granite-granodiorite north of Winokapau Lake. A body of similar size also occurs in the central part of the granulite paragneiss. Quartz, K-feldspar, plagioclase, hypersthene and minor biotite are the main constituents. The body north of Winokapau Lake is highly deformed with a cataclastic texture. It is fault bounded on the north and its eastern margin runs close to a presumed metamorphic facies change from amphibolite to granulite grade. The southern body is approximately rectangular, bounded on two sides by faults and on the remaining two sides forming an intrusive contact within host gneiss.

Foliated Granite and Orthogneiss (unit 4)

The metamorphosed granitoid rocks are divided into two main subunits. Porphyritic granite to granodiorite (unit 4a) is most common in the central and southeastern parts of the area. It consists of abundant megacrysts of microcline up to 2 cm set in a medium grained groundmass of quartz, plagioclase, orthoclase, biotite and hornblende. A variety of metamorphic and structural characteristics are displayed. Porphyritic granite-granodiorite may be moderately to strongly foliated, lineated or banded. Where lineated, primary igneous texture is preserved on outcrop faces normal to the plunge of the lineation, and megacrysts are attenuated on faces parallel to the lineation. With increased deformation and metamorphism, total recrystallization takes place resulting in formation of orthogneiss (unit 4b). The mineralogy remains the same except for the addition of euhedral garnets up to several millimetres in size. Igneous texture is completely altered to coarse, granoblastic polygonal texture although megacrysts remain as lenticular augen. With extreme deformation, the megacrysts are strung out to form quartzofeldspathic bands. Since intense deformation is widespread throughout the area and low strain zones are present only locally in fold noses, banded or augen orthogneiss predominates over its megacrystic protolith.

No contacts between paragneiss of unit 1 and rocks of unit 4 were observed, but sillimanite-bearing paragneiss xenoliths are present within porphyritic granodiorite and orthogneiss in the adjoining map area (see Nunn and Christopher, 1983). Indications are that the granitoids intruded the paragneiss terrane prior to at least the last major period of deformation.

North Pole Brook Intrusive Suite (unit 5)

Quartz diorite to granodiorite, present in the northern part of the area, exhibits relict equigranular igneous texture and is much less deformed than the orthogneiss. It consists of quartz, K-feldspar, biotite, hornblende and magnetite. Although strongly foliated in the map area, it can be traced northwards into almost undeformed equivalents, which have been collectively termed North Pole Brook Intrusive Suite by Thomas and Hibbs (1980). This unit is intrusive into older polydeformed amphibolite grade paragneiss north of the Churchill River, but could not be traced south of the river into orthogneiss which is thought to represent its higher grade equivalent.

Foliated Quartz Diorite to Diorite (unit 6)

Confined to three small bodies south of the Churchill River and Winokapau Lake, quartz diorite-diorite consists of quartz, K-feldspar, plagioclase, hornblende, minor biotite and magnetite. The rock is dark green, almost black on weathered and fresh surfaces, and in places approaches gabbroic composition. No contacts were observed, but the bodies probably represent younger intrusives within the amphibolite grade paragneiss.

Shabogamo Gabbro (unit 7)

Gabbro is present within the amphibolite grade paragneiss terrane as narrow, elliptical bodies, probably representing disjointed and boudinaged sills. Although the bodies are metamorphosed, relict igneous textures are preserved within their centres; corona textures are present locally. Orthopyroxene, clinopyroxene, abundant magnetite-ilmenite and plagioclase are the main constituents. The bodies tend to be extremely coarse grained in their centres, and fine grained and recrystallized along their margins. They intrude amphibolite grade paragneiss and orthogneiss and are correlated with the Shabogamo Intrusive Suite, widely exposed throughout western Labrador.

Foliated to Massive Granite (unit 8)

This is the least tectonized rock in the area and is thought to be quite young. Granite characterized by coarse, equigranular grain size and plutonic, igneous texture occurs in a small body south of Winokapau Lake. It consists of quartz, orthoclase, plagioclase and biotite with minor magnetite or ilmenite. Xenoliths of mafic to quartzofeldspathic paragneiss are abundant within the granite which is bleached along the xenolith contacts. The body has intruded a previously deformed gneiss terrane and may have had its origin in the partial melt fraction derived during the metamorphism of those same gneisses.

Structure

No major regional structures were observed due to a combination of poor exposure, especially along contacts between different rock types, and lack of continuous passive marker horizons within individual units. Therefore, all fold closures and axes are inferred from variations in trends of gneissic banding, foliation and approximated contacts between contrasting rock types. Figure 42.5 shows the major structural elements within the Winokapau Lake map area. It is emphasized that the structural inferences made are preliminary and have to undergo more rigorous testing by the data which have not yet been fully compiled. Four major periods of deformation are postulated, with evidence for four phases of folding and as many faulting events. Figure 42.6 pictorially illustrates a possible theoretical structural interpretation for rocks within the map area.

The first period of deformation resulted in the creation of a well developed gneissic and primary melt banding. The banding has a moderate to steep dip and is parallel to F_1 isoclinal fold axes about which it has been folded by D_1. The original trend of these axes has been changed by later deformations, but may have been east-west. During D_2, F_1 isoclinal structures were folded about closed to tight northwest-southeast F_2 fold axes. A second melt banding consisting of quartz-feldspar veinlets which crosscut the primary gneissic banding also formed at this time. Under the effects of D_3, F_1 and F_2 regional structures were deformed about east-trending F_3 fold axes into isoclinal mushroom and dome and basin fold patterns. The D_2 melt banding was ptygmatically folded and a third system of crosscutting partial melt veinlets formed, as well as associated tourmaline pegmatite dykes.

Stretched augen, mineral elongation and mineral streaking define a consistent pattern of strongly developed lineations (Fig. 42.7) presently thought to be associated with F_3 structures within the amphibolite grade paragneiss and orthogneiss. The lineations plunge at an angle of approximately 40° on a bearing of 155° and indicate a probable northwesterly transport direction for bulk rock movement during D_3. The trend of these lineations is strikingly similar to those within the Red Wine Mountains massif to the northeast (see Emslie et al., 1978, Fig. 27.3).

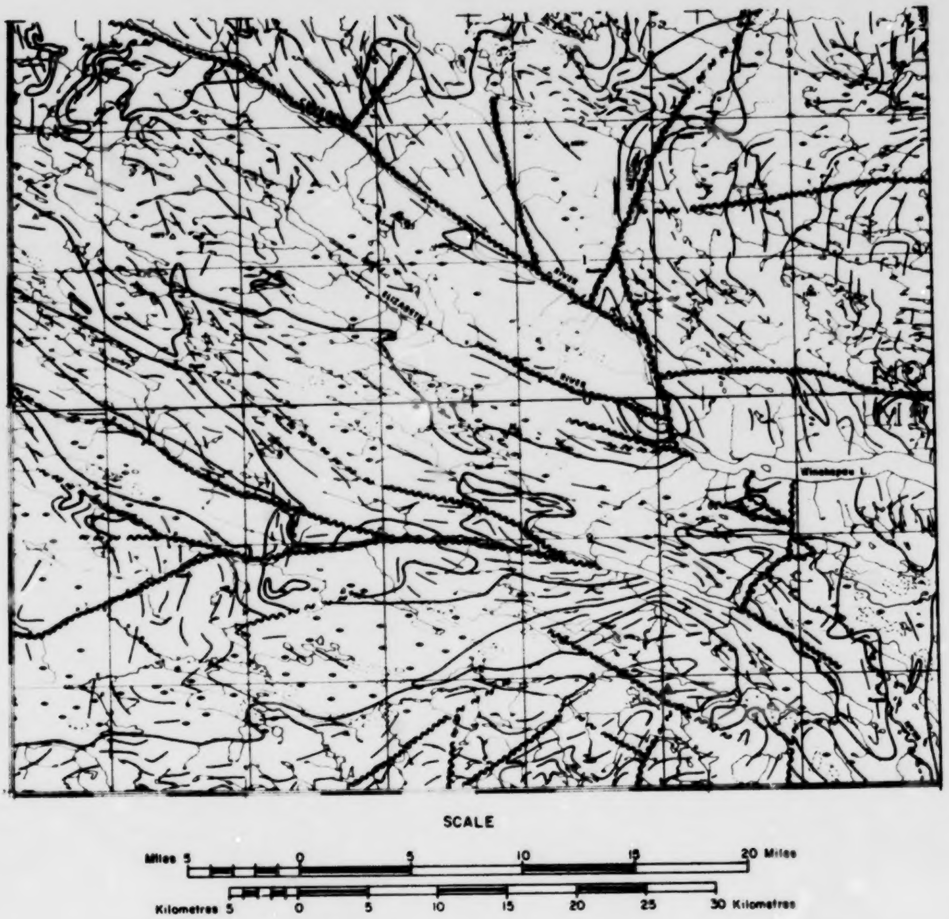
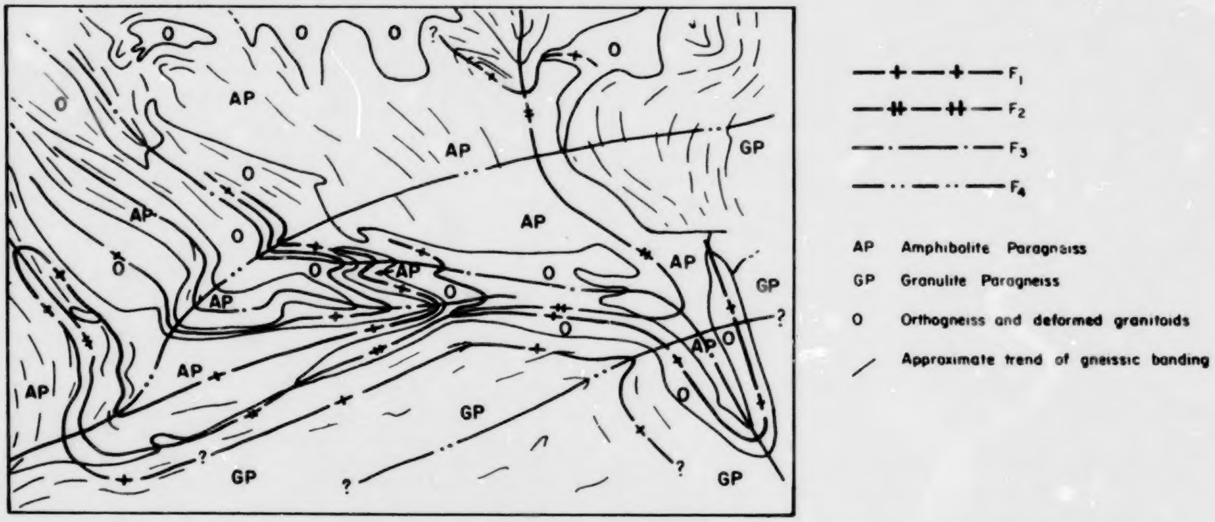


Figure 42.5. Structural grain in the Winokapau Lake area, based on trends of gneissic banding and foliation.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AP Amphibolite Paragneiss
GP Granulite Paragneiss
O Orthogneiss and deformed granitoids
Approximate trend of gneissic banding

Figure 42.6. Pictorial diagram (not to scale and neglecting effects of faulting) illustrating possible structural interpretation of rocks around Winokapau Lake.

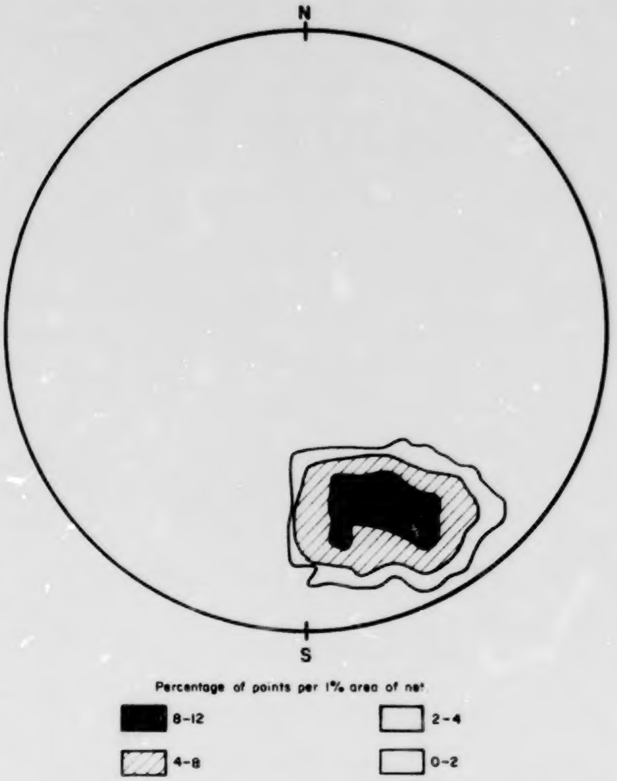

Figure 42.7. Contoured lower hemisphere stereographic plot of lineations from the amphibolite paragneiss, orthogneiss and granitoids (based on 56 data points).

The most recent deformation (D_4) has resulted in open folding of all previous structures about east-northeast-trending F_4 fold axes. This has caused F_3 fold structures to open up and F_2 fold structures simultaneously to become more attenuated. The D_3 melt veinlets have been strongly deformed whereas the associated pegmatite dykes were more gently deformed into open minor folds.

In Figure 42.6, structures have been tentatively extended from the amphibolite grade paragneiss and orthogneiss into the granulite grade paragneiss terrane. In the adjoining area to the west, there is limited evidence to suggest that the granulite gneiss constitutes a separate structural block which acted as a buttress against some of the deformation within the amphibolite grade rocks. If this turns out also to be the case in the Winokapau Lake area, the above structural extension may be invalid.

No attempt is made to correlate faults within the map area with deformation events responsible for folding. All faults are based on one or more of the following criteria: (1) presence of fault breccia; (2) shear and/or mylonite zones; (3) slickensided surfaces associated with shearing; (4) mismatch of lithological units across lineaments; (5) scarps associated with shearing and lineaments; (6) well defined lineaments alone.

The earliest generation faults are found within the granulite grade paragneiss. In the eastern granulite terrane, east-west faults have a poorly documented but apparent sinistral component to their movement. In the southern granulite terrane, a conjugate set of northeast and southwest faults are associated with intense mylonitization and shearing.

Second generation northeast- to north-trending faults terminate the east-west faults in the eastern granulite terrane, and at least one is an extremely deep-seated reverse fault. It separates granulite grade paragneiss from the lower grade rocks to the west, and is continuous north of the map area with the major fault that defines the Red Wine Mountains granulite massif. It has also been folded during D_3 and cut by Shabogamo gabbro. In addition, sometime during its history, the fault underwent ductile movement during a high grade metamorphic event. Evidence for this is the presence of syntectonic sillimanite, having a preferred orientation within the plane of the fault.

A single fault running south from the west end of Winokapau Lake constitutes evidence for third generation faulting.

The numerous fourth and last generation faults are reflected in the northwest- to west-trending drainage pattern. They are fundamental structures along which preglacial and postglacial erosion has taken place to produce spectacular deep gorges. These gorges normally contain abundant glaciofluvial deposits and it is obvious that the fourth generation faults have influenced the orientation of postglacial spillways and more recently regenerated drainage. Erosion along one of these faults has created the Churchill River gorge through which the entire runoff of the Smallwood Reservoir (formerly Michikamau Lake) catchment area flows. The fourth generation faults terminate or impart a sizeable left lateral offset component to second generation faults, and the Churchill River fault which continues through Winokapau Lake terminates the third generation fault.

First and second generation faults are thought to be extremely old structures which may date back to the Hudsonian Orogeny. The previously mentioned, deep seated reverse fault is probably an ancient structure which has been reactivated several times, the last being during the Grenvillian Orogeny. Third and fourth generation faults are most likely Grenvillian in age and may incorporate significant reverse movement as well as repeated cycles of activation.

Metamorphism

The metamorphic grade of rocks within the Winokapau Lake area varies from amphibolite in the northwest to granulite in the south and east. The division between amphibolite grade and granulite grade rocks is for the most part abrupt. In the east, it runs partly along the reverse fault which juxtaposes rocks of the two facies, and in part constitutes a metamorphic transition. In the south, the nature of the division is unknown. There is no evidence to indicate a gradual increase in metamorphic grade from north to south throughout the area.

Granitoid rocks in the northern and northwestern part of the area exhibit static recrystallization textures and incipient melt zones resulting from a single amphibolite grade metamorphic event. The stable mineral assemblage present is plagioclase, quartz, biotite and hornblende. Paragneiss in contact with these granitoids has been metamorphosed at least once to amphibolite grade. A prograde plagioclase, K-feldspar, quartz, biotite, sillimanite, garnet assemblage is overprinted by retrograde muscovite. Plates up to 1 cm can be found within and discordant to the foliation, but the retrogression is patchy and muscovite-free zones are common.

Both paragneiss and orthogneiss in the central part of the map area have been metamorphosed to amphibolite grade, at least once by the same event which affected granitoids in the northern part of the area. Plagioclase, K-feldspar, quartz, biotite, sillimanite, garnet and muscovite are present in paragneiss; plagioclase, K-feldspar, quartz, biotite, hornblende and garnet in orthogneiss. The development of muscovite is patchy within the central paragneiss terrane, but much more voluminous than in the north and northwest.

Granulite grade paragneiss and gabbronorite in the south and east, chiefly have the assemblages plagioclase, K-feldspar, quartz, hypersthene, sillimanite, minor biotite, and plagioclase, hypersthene, diopside, magnetite-ilmenite respectively. Sapphirine was also tentatively identified. Temperature, total pressure and water pressure constraints on these rocks, require formation near the base of the crust; therefore it is probable that granulite and amphibolite grade paragneisses are respectively deeper and shallower crustal level equivalents of the same unit.

Discussion

Granitoids and orthogneiss are tentatively correlated with less deformed, lower grade equivalent rocks belonging to the North Pole Brook Intrusive Suite, which yield a Rb-Sr isochron cooling age of 1654 ± 22 Ma (Fryer in Thomas, 1981). The amphibolite grade event recorded in both granitoids and orthogneiss at Winokapau Lake must therefore be younger and is probably Grenvillian.

Amphibolite grade paragneiss is correlated with equivalent grade Disappointment Lake gneiss, which is intruded by North Pole Brook granitoids (Thomas, 1981) and was determined by Fryer (personal communication, 1982) to have a preliminary Rb-Sr age of 1666 ± 28 Ma. If this correlation is valid, paragneiss at Winokapau Lake must have been deformed and metamorphosed to amphibolite grade at least twice; once during the Hudsonian Orogeny or an early Paleohelikian event, and again during the presumed Grenvillian event recorded in the granitoids and orthogneiss. The development of three generations of melt-banding within the paragneiss also suggests a history of more than one metamorphic event.

Granulite grade paragneiss is correlated with Hope Lake gneiss (see Emslie et al., 1978; Thomas, 1981; Thomas et al., 1981) which gives a preliminary Rb-Sr errorchron age of 1675 Ma (Emslie in Thomas, 1981). The granulite grade paragneiss at Winokapau Lake has probably experienced a similar metamorphic history to that of the amphibolite grade paragneiss, but due to the anhydrous condition of the rocks no evidence of lower grade metamorphic events remains.

Therefore, although all rocks within the Winokapau Lake area have undergone amphibolite facies metamorphism during the Grenvillian Orogeny, it is possible that granulite grade and in part amphibolite grade events recorded in the paragneiss terrane may be as old as late Hudsonian. At present no thin sections have been examined and the identification of specific assemblages and textures which might enable the separation of earlier and later metamorphic events awaits further work.

Acknowledgments

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GEOLOGY OF THE ATIKONAK RIVER AREA, GRENVILLE PROVINCE, WESTERN LABRADOR[1]

Nunn, G.A.G. and Christopher, A., Geology of the Atikonak River area, Grenville Province, western Labrador; in Current Research, Newfoundland Department of Mines and Energy, Mineral Development Division, Report 83-1, p. 107-114, 1983.

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Abstract

The map area lies within the Grenville Province immediately southwest of Churchill Falls in western Labrador. An area of paragneiss within the Grenville Province is correlated with similar supracrustal rocks of Aphebian age to the west. Posttectonic intrusion by granitoid and gabbroid rocks, tentatively correlated with the Paleohelikian North Pole Brook Intrusive Suite and the Shabogamo Intrusive Suite respectively, indicate that initial deformation of the paragneiss was Hudsonian or early Paleohelikian. A zone which might contain the approximate continuation of the Hudsonian front in the Grenville Province is suggested.

Introduction

This report presents the results of the first part of a two year co-operative program between the Geological Survey of Canada and the Newfoundland Department of Mines and Energy. The aim of the project is to elucidate the stratigraphy and tectonic evolution of the Atikonak River area in western Labrador. The project area includes NTS map areas 23H/1, 2, 7 and 8 (Fig. 51.1). These were mapped at 1:100 000 scale using helicopter support.

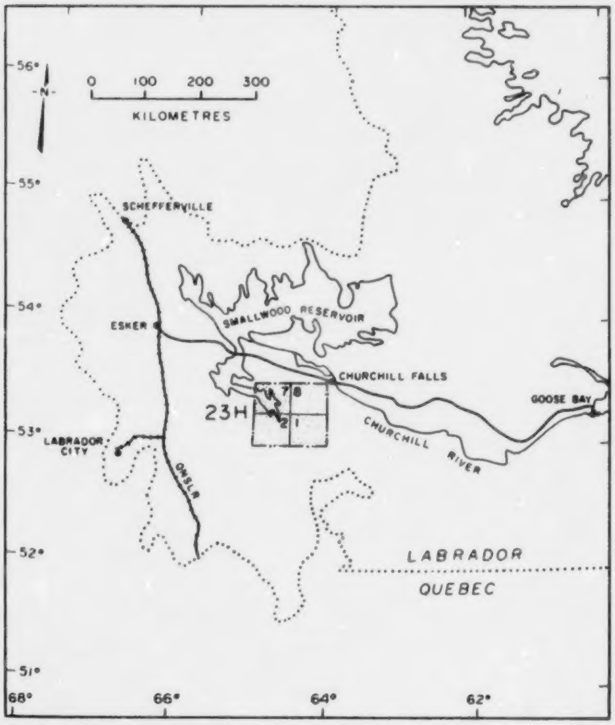

Figure 51.1. Location map of the Atikonak River area, western Labrador.

The physiography of the area is dominated by Ossokmanuan Lake, a flooded area that forms part of the Smallwood Reservoir. No correction for flooding has been made to the map. Access to the western part of the area is from Ossokmanuan Lake, the Atikonak River or a road from Churchill Falls to the power transmission line. Access to the remainder of the area is by helicopter.

Previous Work

Earlier work in the area comprises reconnaissance mapping by Eade (1952) at 1:126 720 scale, and Wardle (1982). Eade described an older complex of granitic paragneiss, gabbroic gneiss, amphibolite and garnet-, biotite-, and chlorite-bearing schist, intruded by younger, undeformed gabbro. Greene (1972, 1974) divided the granitic paragneisses into those with assumed Aphebian or older parentage in the west and those of supposed Helikian origins in the east. Smyth and Green (1976) positioned the northern boundary of the Grenville Province in the area giving it a lobate form separating the two gneissic groups of Greene (1972) within the Grenville Province from a re-entrant underlain by undeformed gabbro that was excluded from the Grenville Province.

Wardle (1982) noted that both western and eastern lobes were apparently the same assemblage of polydeformed and migmatized sillimanite-bearing paragneiss that was subsequently intruded by pre- and late-tectonic granitoid plutonic rocks. Wardle (1982) interpreted the gabbroic gneisses of Eade (1952) as deformed equivalents of the younger gabbro and considered that the whole area lay within the Grenville Province.

General Geology

The map area (Fig. 51.2) is divided into two metamorphic terranes that coincide with peneplain levels at 875 m and 680 m. The upper peneplain is underlain by granulite facies rocks, the lower one by amphibolite facies rocks. Locally a mylonite has been mapped at the contact between the two facies and the boundary is assumed to be a thrust fault.

Unit 1 (Fig. 51.2) is composed of strongly migmatized sillimanite-bearing paragneiss at granulite and upper amphibolite facies and is the oldest lithology. recognized in the map area. Retrogression is of only minor significance and occurred late during the Grenvillian Orogeny. Neither Wardle (1982) nor the writers find sufficient reason to separate the amphibolite and garnet-, biotite- or chlorite-bearing schist unit of Eade (1952) although amphibolite (metagabbro of unit 3) and biotite-garnet paragneiss (unit 1) are minor lithologies near Ossokmanuan Lake.

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[1] Contribution to Canada-Newfoundland co-operative mineral program 1982-84. Project carried by Geological Survey of Canada.

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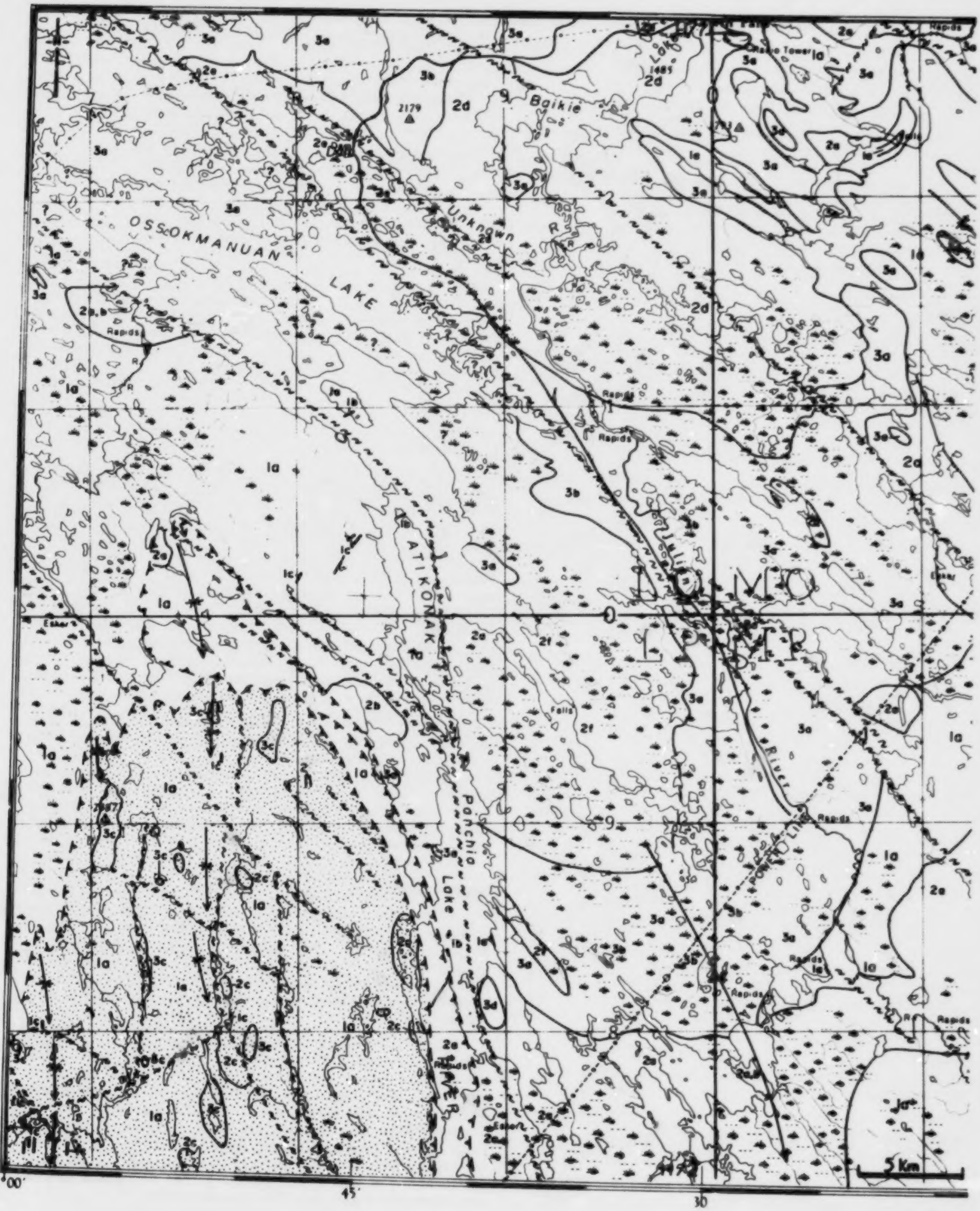
OSSOKMANUAN LAKE
Unknown R.
Baikie Lake
ATIKONAK RIVER
Ponchio Lake
Julian River
Radio Tower
POWER LINE
Rapids
Falls
Eskers
2179
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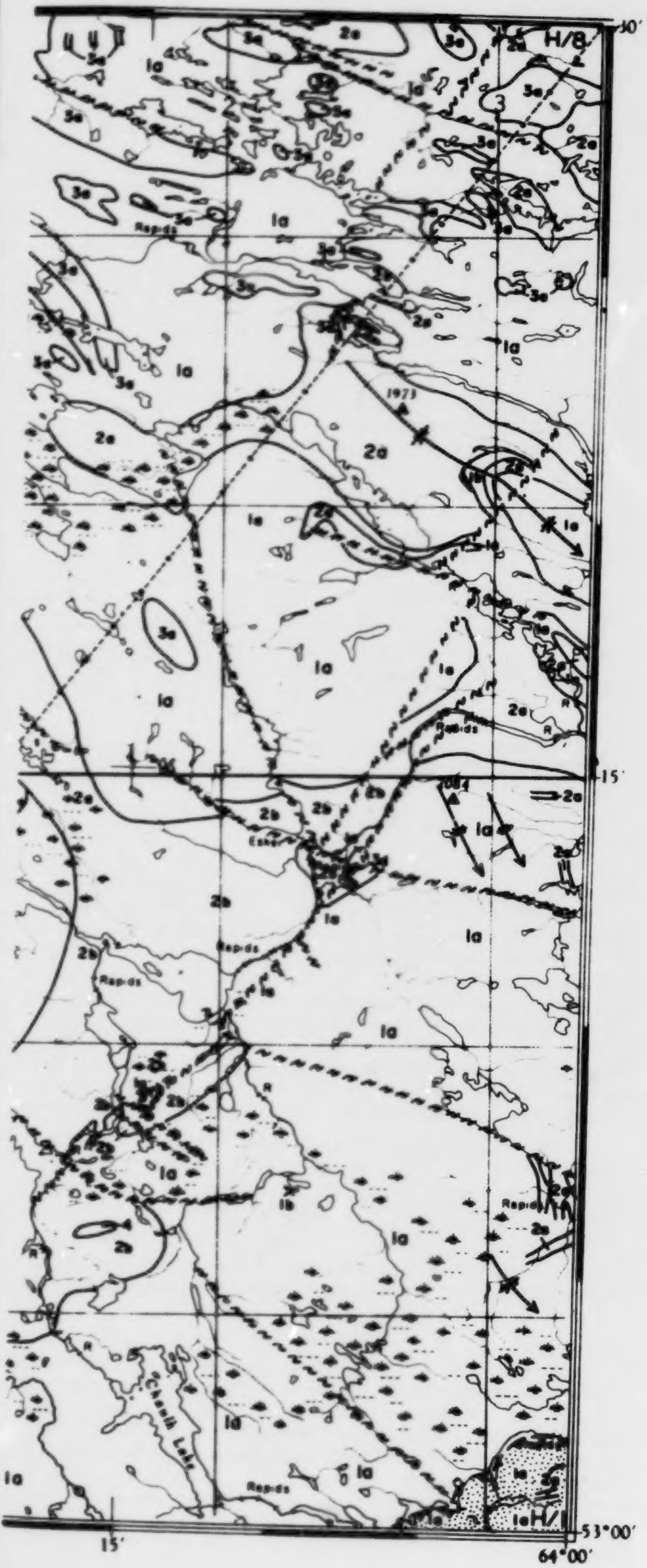

LEGEND

NEOHELIKIAN ?

Unit 4. White, very coarse grained muscovite granite.

PALEOHELIKIAN ?

Unit 3. Shabogamo Intrusive Suite?:

- **3a** Fine- to coarse grained, intergranular textured gabbro and leucogabbro and their amphibolite facies metamorphosed equivalents, commonly with coronas; minor pegmatite;
- **3b** fine- to coarse-grained, layered gabbroic rocks and their amphibolite facies metamorphosed equivalents;
- **3c** fine- to medium-grained, equigranular, granulite facies leucogabbro with minor gabbro, ultramafic rock and anorthosite; minor intergranular textured gabbro and fine grained dykes.

Unit 2. Orthogneiss and foliated granitoid rocks: Possible equivalents of the North Pole Brook Intrusive Suite (Thomas and Hibbs, 1980).

- **2a** grey, fine- to medium-grained, static textured, granodioritic and tonalitic rocks, variably migmatized ranging from homogeneous to lit-par-lit layered, granite or trondhjemite leucosomes;
- **2b** grey, megacrystic granodiorite, groundmass fine-to medium-grained, static textured; coarse porphyritic to fine porphyroblastic microcline megacrysts;
- **2c** buff, medium- to coarse-grained, strongly foliated, microcline porphyritic, quartz monzonite;
- **2d** grey, medium grained, sphene-rich, microcline porphyritic, quartz monzonite; moderately to strongly foliated and migmatized;
- **2e** pink, fine-to medium-grained, granite layered, granodioritic gneiss; very strongly migmatized;
- **2f** pink, fine- to medium-grained, statically recrystallized, biotite granite and aplite, rarely weakly migmatitic.

APHEBIAN

Unit 1. Paragneiss.

- **1a** pink, granite migmatite banded; either strongly foliated sillimanite + opaque oxide ± minor biotite restite or statically recrystallized sillimanite + biotite + garnet restite;
- **1b** thin, discontinuous quartzite, and subarkosic and arkosic arenite;
- **1c** fine grained, pyroxene-bearing basic gneiss, probably supracrustal with minor dykes;
- **1d** fine grained, pyroxene-bearing metabasic rocks in amphibolite facies areas.

SYMBOLS

Geological contact (assumed)

Thrust, teeth on upthrust block (assumed)

Fault and major photo lineaments (assumed)

Fold axis – GD_4; anticline, syncline (assumed)

Granulite facies

? Uncertain, dominantly drift covered areas

Figure 51.2. Generalized solid geology of the Atikonak River area.

Unit 1 has been intruded by a plutonic suite (unit 2) consisting of granitoid rocks ranging in composition from diorite to granite.

Unit 3 consists of a variety of gabbroic rocks including rocks correlated with the Paleohelikian Shabogamo Intrusive Suite, a major intrusive feature of the northern Grenville Province in western Labrador.

Unit 4 comprises late syntectonic to posttectonic granite dykes (not shown on the map) and a small, very coarse grained body of muscovite granite. Widespread development of late Grenvillian intrusions was not found during this study. Several minor units previously considered Grenvillian (Wardle, 1982) are thought to be a part of unit 2.

No age dates are available for rocks within the map area.

Unit 1: Supracrustal Gneisses

Unit 1 is composed of paragneiss, and minor metabasic supracrustal rocks which are mostly confined to the southwestern portion of the map area. Bulk compositional variation within the paragneiss is rare suggesting a homogeneous protolith.

Migmatitic paragneiss (unit 1a). The paragneiss includes pinkish brown and grey banded rocks in which partial melting has produced a location fabric[1] of alternating layers of granitic melt and aluminous restite, and several generations of crosscutting migmatitic granite veins. Layering representing the initial melt is pink to brown weathering, several millimetres to one centimetre thick and forms the most regular banding. It is composed of fine- to medium-grained quartz + feldspar ± biotite ± opaque oxides ± garnet ± sillimanite. The restite occurs as 0.5-3 mm thick, white to grey foliae composed of either sillimanite + biotite + magnetite ± garnet, or sillimanite + opaque oxides ± a fine grained biotite selvage. Paragneiss with biotite-rich restite occurs only in northern and northeastern parts of the area. Kyanite has been recorded from the northern margin of the area (Wardle, 1982). Later generations of migmatitic veins are pink, medium grained, 1-2 cm thick and consist of microcline + quartz + plagioclase + biotite ± magnetite ± garnet. Wherever this later migmatization is well developed the restite is more prominent. Crosscutting dykes composed of biotite or two-mica granite are also present.

In places the rock forms an inhomogeneous diatexite with patches of restite within areas of coalesced melt. Gradations occur between the isotropic granitoid-looking migmatite and the layered migmatitic gneiss. The gradational rocks usually contain palimpsest structures and the areas of coalesced melt appear to have remained in situ. However, nebulitic, sheet-like examples of the diatexite indicate local mobility as dykes.

Homogeneous sedimentary layers (unit 1b). Locally, homogeneous, nonmigmatitic layers occur intercalated with the main paragneiss. They consist of quartz + feldspar ± biotite ± opaque oxides and appear to have been derived from arkosic to quartz arenites. Thin layered quartzites are also present and commonly occur as trains of boudins or as thin layers associated with amphibolite. A thick, folded quartzite layer is present in the east of map area H/8.

Metabasic rocks (unit 1c). Basic gneiss is interlayered with the paragneiss in the western part of map area H/2, and includes a few layers, several tens of metres thick, and abundant thinner, less continuous layers, enclaves, and trains of boudins. The thicker layers are net-veined or sheeted by granitoid material. The basic gneiss consists of plagioclase + orthopyroxene + diopside + hornblende; a quartz-rich segregation layering is common. In the eastern part of the area the metabasic rocks (amphibolite) are much less abundant than in the southwest. The intimate intercalation of the basic gneiss with paragneiss, including quartzite, appears primary and indicates that the metabasic rocks are probably of volcanic origin.

Other thinner, boudinaged metabasic layers, which locally preserve relict porphyritic texture and fine grained margins, are derived from mafic dykes.

The age of unit 1 has not been determined directly. However, the paragneiss is contiguous with lithologically similar rocks that extend over 100 km to the west into the Wabush area (T. Rivers, personal communication, 1982). There, Rivers (1980) has interpreted them to be the deformed and metamorphosed equivalents to Aphebian greywackes and shales of the Labrador Trough. Rb-Sr dates in the same area have indicated a Grenvillian age of metamorphism of this sequence. The paragneiss extends to the northeast into the area of the Red Wine Mountains where it has yielded circa 1660 Ma ages of metamorphism (B. Fryer, personal communication, 1982). At present it is uncertain whether the paragneisses in the Ossokomanuan area were formed by Grenvillian, Paleohelikian or Hudsonian events. In all probability they are polyorogenic.

Unit 2: Orthogneiss and Foliated Granitoid Rocks

This unit comprises a variety of predominantly granodioritic to quartz mozonitic lithologies that are intrusive into unit 1.

Migmatitic granodiorite and tonalite (unit 2a). In the east, northeastern and central parts of the map area grey, fine- to medium-grained, hornblende-biotite granodiorite and tonalite occur. Homogeneous, and randomly to lit-par-lit migmatized types are present.

Central megacrystic granodiorite (unit 2b). This unit consists mostly of homogeneous, foliated, megacrystic granodiorite with euhedral to rounded K-feldspar megacrysts up to 5 cm long. The unit is rarely gneissic. Relict megacryst cores are grey to purple, contain primary biotite and plagioclase inclusions, and have been partly polygonized during posttectonic recrystallization. The megacrysts are thought to be of primary origin. Partial melting was rare but, where present, apparently did not affect the megacrysts, despite experimental predictions to the contrary (Wyllie et al., 1976).

The unit also contains a finer megacrystic facies characterized by 0.5-1 cm diameter, ragged, microline crystals that appear to represent porphyroblasts developed in originally equigranular granodiorite. Both facies contain nonmegacrystic rocks with which there are no sharp contacts.

Dykes of coarse augen granodiorite are intrusive into paragneiss of unit 1, and the megacrystic granodiorite also contains inclusions of paragneiss.

Megacrystic quartz monzonite (unit 2c). This unit occurs in the southwestern part of the area and is composed of strongly foliated, megacrystic, quartz monzonite. The medium grained groundmass contains biotite and probably orthopyroxene. One body contains xenoliths of folded migmatitic paragneiss.

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[1] Distribution of fabric elements in (3D) layers.

Sphene-rich, megacrystic quartz monzonite and gneissic equivalents (unit 2d). Foliated, megacrystic, biotite-hornblende-quartz monzonite is characteristic of the area north of Baikie Lake. Relict K-feldspar is common and sphene is an abundant accessory mineral. Migmatization was confined to a few discordant veins commonly following the locus of small shear zones. To the east, west and south the granitoid rocks become progressively deformed and recrystallized. K-feldspar is replaced by elliptical aggregates of microcline, and evidence of late migmatization, consisting of discordant quartzofeldspathic veins with large poikilitic hornblende grains, is more abundant. Further deformation induced attenuation of the feldspathic aggregates, imparting a banded appearance to the rock that is enhanced by concordant veins of anatectic granite and aplite. Discordant, migmatitic veins with poikilitic hornblende are also present but sphene was not observed. Diorite inclusions are rare.

Pink, granite banded orthogneiss (unit 2e). A strongly banded orthogneiss consisting of a pale grey, granodioritic paleosome and pink, granitic, migmatitic layering outcrops between Baikie Lake and Ossokmanuan Lake. The granitic layers range from centimetre-wide veins to metre-thick dykes and dominate the lithology. Both granite and granodiorite contain hornblende, biotite and epidote; the epidote appears stable and is located at plagioclase-hornblende grain boundaries.

Pink granite (unit 2f). Pink, biotite-bearing aplite and fine grained granite occur at the southern end of Ossokmanuan Lake. These contain a vague migmatite banding defined by slightly coarser aplitic phases.

Correlation of unit 2. The rocks around Baikie Lake (unit 2d) are the southerly continuation of the granitoid gneisses (unit 9) of Wardle and Britton (1981). The remainder of unit 2 is similar to other members (units 6, 7 and 8) of the granitoid plutonic lithologies of Wardle and Britton (1981) which pass north into weakly deformed plutonic rocks apparently intruded circa 1650-1700 Ma (C. Brooks, personal communication, 1982). Unit 2 as a whole also has features indicating possible correlations with the North Pole Brook Intrusive Suite (Thomas and Hibbs, 1980) in the Red Wine Mountains to the northeast, and the Michikamau plutonic suite (Nunn, 1981; Nunn and Noel, 1982) around Michikamau Lake to the north. The North Pole Brook Intrusive Suite has yielded Rb-Sr ages of around 1650 Ma (B. Fryer, personal communication, 1982). We draw attention to the textural and lithological similarities between this suite and unit 2, and tentatively suggest an equivalent age for unit 2.

Unit 3: Shabogamo Intrusive Suite

The gabbroic rocks in the map area are divisible into three main types: subophitic to intergranular textured gabbro and leucogabbro, layered varieties, and equigranular leucogabbro. In most parts of the area gabbro has generally been emplaced into low structural levels.

Intergranular textured gabbro (unit 3a). The intergranular textures vary from fine- to coarse-grained and consist of randomly orientated plagioclase laths, with a groundmass of pyroxene and magnetite. Olivine was recorded by Wardle (1982). Pegmatitic patches with intergranular textures are common and grade into the normal gabbro. The pegmatites generally preserve primary gabbro mineralogy as purple plagioclase laths, up to 20 cm long, intergrown with shiny, grey pyroxene (?bronzite). In the finer grained rocks the primary mineralogy is preserved only in eastern parts of map area H/7; elsewhere corona textures or alteration to an amphibolite facies mineralogy prevail. Several mineralogical variations occur in the coronas:

i) Amorphous brown core (altered olivine?) ± pale fibrous zone (orthopyroxene or termolite?) + deep green fibrous zone of actinolite + garnet + plagioclase.

ii) Matt black, uncleaved, mafic mineral (uralite?) ± garnet + white, granular plagioclase ± relict, green, saussuritized plagioclase cores.

iii) ± relict orthopyroxene + green hornblende and/or biotite + garnet + plagioclase.

The first two types may have developed in response either to igneous re-equilibration or to metamorphism. They occur only in areas where primary textures are well preserved. The third type is a metamorphic corona.

Layered gabbros (unit 3b). Layered gabbro is not as abundant as the unlayered unit. The layering results from variations in mineral proportions and grain size heterogeneities. Layered gabbro is exposed in the body west of Baikie Lake where composition ranges from gabbro to leucogabbro with minor anorthositic layers. Mineralogical grading, inclusions of underlying layers, and igneous lamination are present and primary mineralogy and corona types (i) and (ii) are common. Compositional layering also occurs in gabbro bodies in the southeast of area H/7 and farther south in the area of the power line. Most of these gabbros are strongly deformed and metamorphosed and pyroxene is pseudomorphed by hornblende or is left as relicts rimmed by biotite. Garnet occurs as coronas or is disseminated within recrystallized plagioclase.

Equigranular leucogabbro (unit 3c). Almost all of unit 3 in the southwestern area is equigranular leucogabbro. The unit is dominated by fine grained, two-pyroxene leucogabbro with minor hornblende; the main ferromagnesian minerals being orthopyroxene and diopside. Clinopyroxene or hornblende occur as rare coronas round orthopyroxene, and garnet is a rare accessory. The leucogabbros are mostly homogeneous, lacking any layering, contain coarser grained sweats, and are weakly foliated with a polygonal texture. They are cut by finer grained dykes of similar composition and also contain a few coarse grained, gabbroic to ultramafic patches net-veined by anorthositic material. The leucogabbro may be unrelated to the intergranular and layered gabbros.

Two-pyroxene metagabbro (unit 3d). Two bodies containing metamorphic mineral assemblages of plagioclase + orthopyroxene ± diopside ± hornblende ± biotite occur in the south and east of the area. The surrounding paragneiss, orthogneiss and gabbro, however, contain amphibolite facies assemblages.

Contacts between unit 3 and other units have not been observed and the relative ages of units 2 and 3 are not known. The intergranular textured gabbro west of Baikie Lake is continuous to the west with gabbro of the Shabogamo Intrusive Suite (Rivers, 1982). Textural comparison with this suite (cf. Fahrig, 1967; Rivers, 1980; Wardle and Britton, 1981) also indicates that a preliminary correlation can be made with the remainder of unit 3. The Shabogamo Intrusive Suite has been dated at 1375 ± 60 Ma (Brooks et al., 1981) to the northwest of this area.

Unit 4: Alkali-Feldspar Granite

This unit, a white weathering, very coarse grained, alkali-feldspar granite, occurs in the southeast of the area. The granite contains abundant muscovite, magnetite and

Table 51.1

Summary of chronology incorporating structural and metamorphic events

UNIT	EVENTS	FOLDING, FAULTING	FABRICS	MIGMATIZATION	METAMORPHIC GRADE
1	*Deposition*				
	Basic dykes				
	HD_1		*HS_1, Location fabric in (1a, c)*	*HM_1, major*	*Au +*
	HD_2	*HF_2, rare insoclines in (1a)*			*A +*
	Basic dykes				
2	*Intrusion*	*relative ages unknown*			
3	*Intrusion*				
	GD_1	*GF_1, isocline(s?) in (3b)*	*GS_1, Location fabric weak in (2b, f) variable in (2a, d), strong in (2e)*	*GM_1, possible range in (1)*	*A +*
	GD_2 early	*GF_2, tight to isoclinal in (1, 2), thin shear zones in (3)*	*GS_2, major, mineral and shape fabrics in (1, 2, 3)*	*GM_2, minor + late to post-tectonic sweats*	*Au north* *G south*
	- late	*Thrusting, possible range or regeneration*	*Mylonite*		*Au*
	GD_3, possible range	*Thin shear zones in (2)*	*GS_3, diorite in (2d) only*	*GM_3, possible range in shear zones only*	*A*
	Basic dykes?				
	GD_4	*GF_4, open to tight, regional map scale*			
4	*Intrusion*			*2-mica and muscovite-bearing granite dykes*	*A*
	D	*Faulting*			*Gs*

Numbers in parentheses refer to legend and text.

A, amphibolite; Au, upper amphibolite facies; G, granulite facies; Gs, greenschist facies; + denotes "or higher"; north and south are regional designations referring to the two metamorphic terrains (see text).

minor biotite and a small xenolith of folded paragneiss restite. Although this rock could be a part of unit 2, we suggest, because of primary igneous textures and a lack of deformation, that it could be the end product of Grenvillian migmatization: an "S-type" granite.

Related late and posttectonic granite dykes and milky quartz veins are present throughout the area but are not represented on the map. The dykes are commonly graphic and muscovite ± biotite-bearing. Both the dykes and the quartz veins have alteration halos in the adjacent paragneiss in which muscovite has partly or wholly replaced restite foliae for distances of up to 2.5 m from the contacts. Unit 4 dykes intrude all other units.

Structure and Metamorphism

Table 51.1 summarizes the structural amd metamorphic history of the area. Pre-Grenvillian deformation is assumed to be Hudsonian (HD) but conceivably could be early Paleohelikian in age. All units were strongly deformed and metamorphosed in the Grenville Orogeny (GD).

The earliest structure recognized in the area is the migmatitic layering that is pervasive throughout most of unit 1. It occurs as layers of granitic melt in the paragneiss (unit 1a) and as a quartz segregation layering in the basic gneiss (unit 1c). The layering formed during the first deformation HD_1 which occurred at upper amphibolite or higher metamorphic grade. Relict HD_1 prismatic sillimanite forms dense lineated mats parallel to the restite foliae.

Rare examples of isoclinal folds of the layering formed during HD_2. They predate the intrusion of basic dykes and K-feldspar megacrystic granitoid rocks in the southwest.

The deformation sequence is divided by the emplacement of units 2 and 3 which are taken to represent markers between Grenvillian and older deformation.

GD_1 is represented by isoclinal folding of layered gabbro in unit 3 and by variable degrees of migmatization in unit 2. Crosscutting migmatitic veins in unit 1 were probably developed at this time.

The metamorphic facies attained during the HD_2 and GD_1 events are unknown because there are no surviving index minerals that may be confidently assigned to either of these events. However, two metabasic bodies (unit 3d) in the south and east of the map area contain orthopyroxene + diopside assemblages indicating that metamorphism during GD_1 may have peaked in the lower granulite facies.

GD_2 structures represent a major structural reworking throughout the area. Concordant and crosscutting migmatitic veins of HD_1 and GD_1 generation in both the paragneiss and the orthogneiss units were tightly to isoclinally folded during GD_2 with the development of a strong axial planar mineral foliation in most lithologies. Syntectonic axial plane-parallel migmatization was minor but this fabric was greatly enhanced by the intense transposition of the pre-existing location fabrics. Fold mullions, augen gneisses and a strong shape and mineral rodding indicate an extensional strain regime. Lineations generally plunge south-southeast at moderate angles.

The gabbroic rocks of units 3a and 3b responded inhomogeneously to the GD_2 deformation. The foliation of these units is composed of strongly deformed shape aggregates of plagioclase, hornblende and garnet and cuts across GD_1 folds. Foliated gabbro of unit 3a contains augen of relatively undeformed gabbro. Some augen and the large body west of Baikie Lake are deformed only in discrete, narrow shear zones which contain an amphibolite facies mineralogy.

The southwestern metamorphic terrane is characterized by a more intense development of the structures during GD_2 compared to the remainder of the map area. The migmatitic layering has a consistent approximately north-trending strike and steep dip, and the fabric in the paragneiss is commonly porphyroclastic or submylonitic in texture. The lineation pitches moderately to steeply to the south on the foliation. GD_2 deformation in unit 3c was more homogeneous and resulted in a penetrative granulite facies mineral fabric.

The GD_2 deformation was accompanied by a pervasive mineral recrystallization. This occurred at granulite facies grade in the southwestern and southeastern parts of the area, where it represented peak metamorphism, and is characterized by mineral assemblages containing sillimanite ± biotite in the paragneiss, and orthopyroxene ± diopside ± hornblende ± biotite ± garnet in the orthogneiss (units 2 and 3). Throughout the remainder of the area upper amphibolite facies conditions prevailed and characteristic index mineral assemblages consist of combinations of sillimanite, biotite, hornblende and garnet. Sillimanite-bearing paragneiss developed fine grained biotite selvages at restite and melt contacts in both granulite and amphibolite facies terranes.

The eastern boundary between the granulite facies uplands and the enveloping amphibolite facies in map area H/2 is a mylonite zone dipping moderately to the west. The remainder of the contact is unexposed. The mylonite is glassy and structurally conformable with the GD_2 foliation and lineation on either side of the zone. Within the granulite facies terrane the foliation is disposed into a map scale synform indicating that the mylonite originated as a deep level ductile thrust along which granulite facies supracrustals were translated northwards over their amphibolite facies equivalents. Although the structural conformity of the mylonite with the GD_2 structures indicates a coeval relationship between the two, the thrusting must postdate the peak metamorphic conditions associated with the formation of the structures (Table 51.1). The mylonite zone is parallel to other high strain zones in the area, both to the east and west. These zones are usually porphyroclastic and less glassy than the example described above.

Post-GD_2 static recrystallization has partly to completely annealed pre-existing fabrics. Coarse grained random needles of sillimanite sporadically overprint the restite foliae in paragneiss of the southern part of the area. Hydration accompanied the recrystallization in the northern areas and the paragneiss is characterized by posttectonic garnet and mimetic textured sillimanite and biotite.

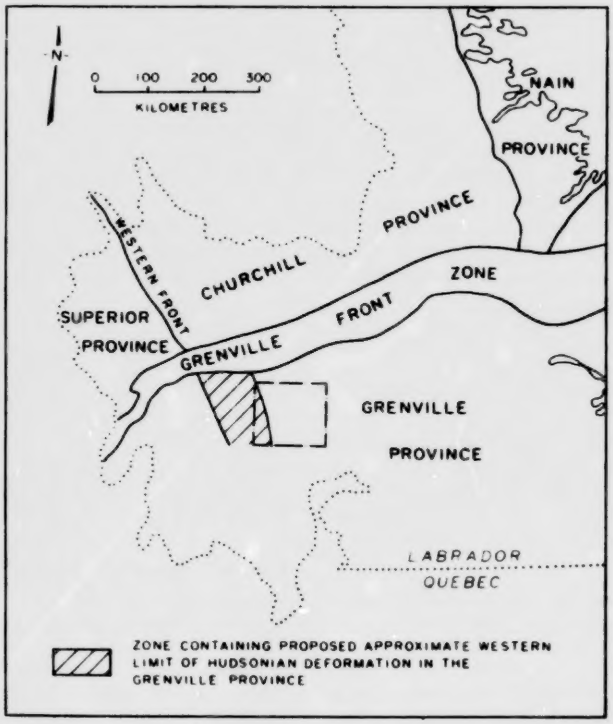

Figure 51.3. *Proposed zone containing the possible extension of the western Hudsonian Front south of the Grenville Front Zone. Province boundaries modified from Stockwell (1961) and Smyth and Greene (1976); Grenville Front Zone modified from Gower et al. (1980) and other work of the Newfoundland Department of Mines and Energy.*

The GD_2 foliation is deflected in shear zones (GD_3) in some of the unit 2 orthogneiss. The shear zones are variable in orientation and may form the locus of late migmatite veins. The veins contain equant quartz and feldspar and coarse grained, poikilitic hornblende.

The map pattern is controlled by regional scale folds (GD_4) that are generally moderate to open. Fold axes fan from north-trending in the southwest to northwest-trending in the northeast. A weak fracture cleavage may be developed in the quartzofeldspathic minerals in GD_4 fold hinges. GD_4 and GD_2 are commonly coaxial but there is no known new mineral growth associated with the later deformation. A retrogressive appearance to some foliation surfaces in the Atikonak River area indicates continuing motion in the thrust zones or reactivation during GD_4.

Muscovite occurs throughout the amphibolite facies area in localized patches or associated with faults and unit 4 pegmatite dykes and quartz veins. The muscovite is always a replacement mineral growing randomly both within and across the restite foliae and in the adjacent melts, and appears to be the result of late retrogression.

Many brittle structures transect the area and postdate GD_4. Two fault systems, in particular, trending approximately 020° and 100°-200°, control the gorge system of the Churchill River (A. Thomas, personal communication, 1982) and its tributaries in the north of the map area. The 100°-120° set has a transcurrent, dominantly sinistral, sense of displacement and appears to be the younger of the two.

Discussion

The metamorphic fabrics in the Helikian granitoid and gabbroic rocks of units 2 and 3 respectively, clearly indicate that the area has been thoroughly affected by high grade, Grenvillian, dynamothermal metamorphism. The strong similarity of fabrics in these units to those in the paragneiss would initially suggest that both formed during the same event. However, several key outcrops suggest that the primary layering developed at different times. Megacrystic granitoid rocks of unit 2, which elsewhere have been migmatized and subsequently further deformed, include paragneiss xenoliths with a melt layering that was clearly folded prior to incorporation. Similar features were described by Wardle (1982) for granitoid rocks south of the area. Some of the paragneiss has, therefore, been deformed by early events prior to the emplacement of orthogneiss and gabbro and is polyorogenic in origin.

Assuming the correlation of unit 2 with the North Pole Brook Intrusive Suite (ca. 1650 Ma) and of unit 3 with the Shabogomo Intrusive Suite (ca. 1375 Ma) the tectonic events recorded in the paragneiss inclusions represent the Hudsonian or an early Paleohelikian orogeny. The Paleohelikian has not yet been shown to be a time of gneiss-forming deformation in central Labrador and the Hudsonian Orogeny is thought to be a more likely cause of early deformation in the paragneiss. The structural boundary between the Churchill and Superior provinces outside of the Grenville Province (Fig. 51.3) is located to the northwest of the map area. The continuation of this boundary, the Hudsonian Front, although probably offset to the east by structural telescoping in the Grenville Front Zone, must still pass to the west of most of the map area (Fig. 51.3).

A similar polyorogenic sequence has been documented affecting gneisses in the Red Wine Mountains (Thomas, Jackson and Finn, 1981) and is suspected in the granulite facies terrane contiguous with the southeastern part of the map area (A. Thomas, personal communication, 1982).

However, a detailed isotopic dating study is needed to confirm the presence of Hudsonian tectonites within this area of the Grenville Province.

Acknowledgments

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PRELIMINARY REPORT ON THE GEOLOGY NORTH OF UPPER LAKE MELVILLE, LABRADOR[1]

Philippe Erdmer[2]

Erdmer, P., Preliminary report on the geology north of upper Lake Melville, Labrador; in Current Research, Newfoundland Department of Mines and Energy, Mineral Development Division, Report 83-1, p. 115-120, 1983.

Also in Current Research, Part A, Geological Survey of Canada, Paper 83-1A, p. 291-296, 1983.

Abstract

Mapping at 1:100 000 scale of 3500 km^2 of the eastern Grenville Province suggests that Aphebian or earlier(?) granitic and tonalitic gneiss complexes, that include supracrustal remnants and metagranitoid rocks, are the oldest rocks of the area. The gneiss complexes were intruded by a late Hudsonian or early Paleohelikian granite pluton, as well as by Paleohelikian anorthositic rocks and later(?) plutons of granite to syenite. A southeast dipping mylonite zone that was probably the locus of thrust faulting coincides with the margin of a half graben filled with Hadrynian(?) conglomerate. Several uranium showings are associated with diatexite developed in parts of the granitic gneiss complex. Strain resulting from the Grenvillian Orogeny is either relatively weak or strongly heterogeneous.

Introduction

This report covers approximately 3500 km^2 of the eastern Grenville Province north of Lake Melville, mapped at 1:100 000 scale during the 1982 field season. It includes NTS 1:50 000 map areas 13F/16, 13G/13, 13G/14 and part of 13J/3 (Figure 40.1).

Eade (1962) and Stevenson (1967, 1970), as a result of reconnaissance mapping of various parts of the area, reported mostly tonalitic and granitic gneiss, commonly with a steeply dipping fabric, intruded by weakly deformed monzonite to granite bodies. Stevenson inferred that the rocks were of Helikian or Aphebian age, or both, and were all affected by the Grenvillian orogeny. Absolute age data remain unavailable. A half graben of Hadrynian (?) arkose and conglomerate (Double Mer Formation) was recognized along the shore of Lake Melville.

Recent systematic mapping of the adjoining areas has been carried out at 1:100 000 scale by Gower (1980), Gower et al. (1981; 1982a, b), Ryan et al. (1981) and Ryan (1982), and at 1:250 000 scale by Emslie (1976; personal communication, 1982). Approximately 200 km^2 of the present map area between Double Mer and Lake Melville, where several uranium showings occur, were mapped at 1:50 000 scale by Bailey (1980).

The area was selected because it provides a link between mapping by Gower et al. (1981) in the east and by Ryan et al. (1981) in the west, and because it contains recently reported uranium-bearing units.

Setting and General Geology

The area lies approximately 100 km south of the Grenville Front, as defined by Gower et al. (1980), within an east-trending belt of Helikian or earlier(?) dominantly tonalite and granodiorite gneiss with supracrustal remnants, that extends through much of western and central Labrador. This belt separates rocks of an extensive, composite granitic batholith to the north, in which individual plutons have yielded ages from 1700-1650 Ma to 1450-1350 Ma (Wardle et al., 1982), from rocks of the Mealy Mountains anorthositic complex (dated at 1640 Ma, Emslie, 1982) to the south (Fig. 40.1). Small half graben filled with Hadrynian or later(?) conglomerate and sandstone are developed in the gneiss belt.

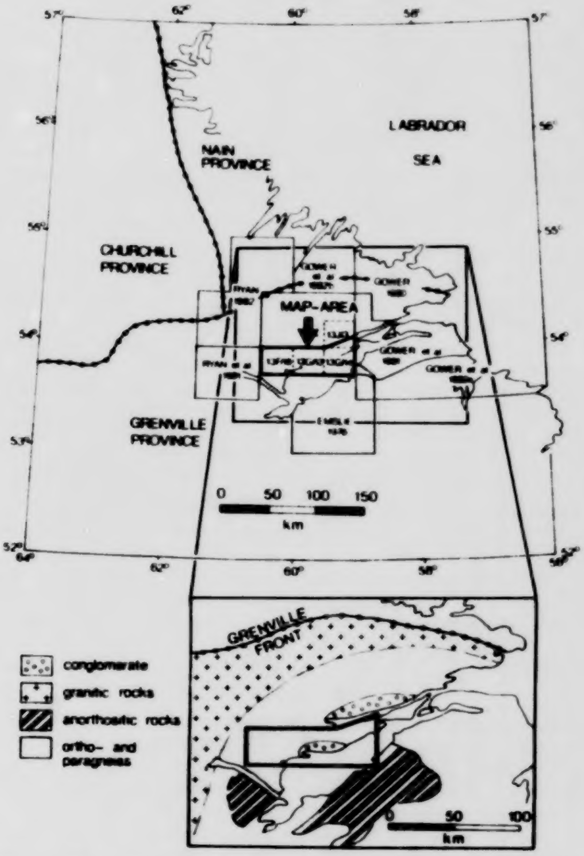

Figure 40.1. Location and setting of the map area. Regional geology is simplified from sources shown.

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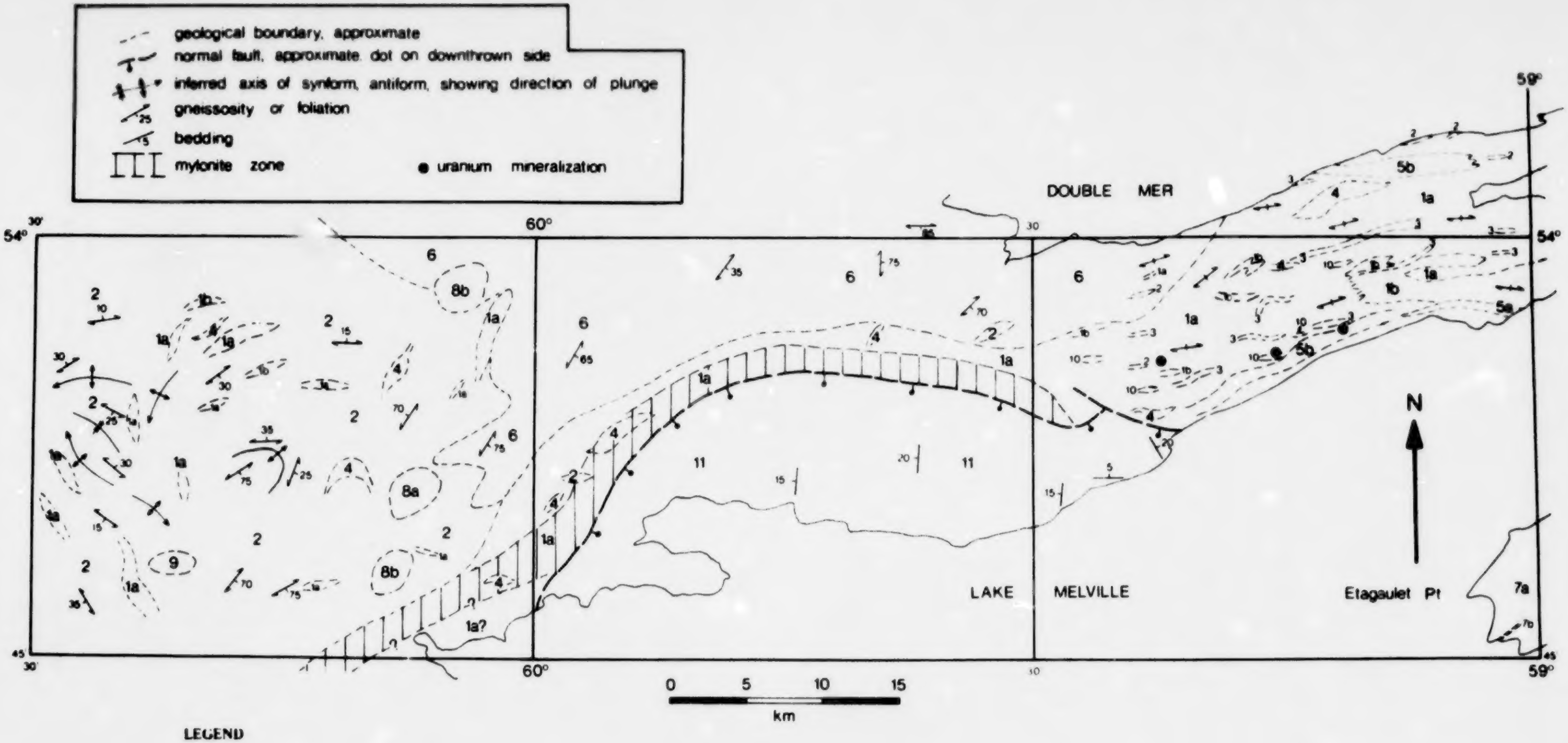
[1] Contribution to Canada-Newfoundland co-operative mineral program 1982-84. Project carried by Geological Survey of Canada.

[2] c/o Newfoundland Department of Mines and Energy, Mineral Development Division, P.O. Box 4750, St. John's, Newfoundland, A1C 5T7.


geological boundary, approximate
normal fault, approximate: dot on downthrown side
inferred axis of synform, antiform, showing direction of plunge
gneissosity or foliation
bedding
mylonite zone
uranium mineralization
DOUBLE MER
LAKE MELVILLE
Etagaulet Pt
N
54°
30'
60°
59°
45
30
0
5
10
15
km

LEGEND

HADRYNIAN

11. **Double Mer Formation:** *Red arkose and polymictic, clast-supported conglomerate.*

HELIKIAN OR EARLIER

10. *Coarse grained, massive, equigranular, white-weathering quartzofeldspathic diatexite.*

9. *Coarse grained, massive metagabbro and hornblendite.*

8. a. *Pink, coarse grained, massive to weakly foliated biotite syenite to quartz syenite.*
   b. *Massive, buff, coarse grained biotite quartz monzonite to granite.*

7. **Mealy Mountains Intrusive Suite (Paleohelikian)**
   a. *Coarse grained, massive, dark gray leuconorite and anorthosite.*
   b. *Fine grained diabase.*

6. *Coarse grained, pink-to-buff granite; massive to strongly foliated.*

5. a. *Coarse grained, pink, megacrystic (K-spar) biotite granodiorite; weakly foliated.*
   b. *Coarse grained, gray augen (K-spar) biotite granite, moderately foliated.*

4. *Medium grained, dark, hornblende dioritic to quartz dioritic gneiss.*

3. *Medium grained amphibolite, micaceous amphibolite and amphibolite gneiss.*

APHEBIAN OR EARLIER (?)

2. *Medium grained, gray (black and white) biotite tonalite to granodiorite gneiss, well banded, migmatitic.*

1. a. *Pink-to-red-to-buff, medium to coarse grained, well banded biotite granitic gneiss, commonly migmatitic and with amphibolite enclaves.*
   b. *Salmon-to-cream colored, fine grained aplitic gneiss to microgranite with amphibolite enclaves, migmatitic in places.*

Figure 40.2. *Generalized geology of the area north of upper Lake Melville.*

Because of extensive forest cover, and drift in low lying areas, exposure in the map area is generally poor, and contacts are not visible. Exceptions are the shoreline and some ridge tops at the eastern extremity of the area, where exposure is excellent.

About two-thirds of the area (Fig. 40.2) are underlain by well layered and strongly folded, partially interlayered granitic gneiss in the east and tonalitic gneiss in the west. As both gneiss units contain interbanded amphibolite, hornblende dioritic gneiss, and granodiorite in various amounts, they constitute gneiss complexes rather than homogeneous units on the scale of the map.

A biotite granite pluton is inferred to intrude both gneiss complexes in the northern portion of the area. It is weakly foliated when compared with the intruded gneiss, which suggests either that Grenvillian deformation was relatively weak in the area, or that strain was heterogenous.

Three small, pre-Grenvillian, almost unstrained plutons of quartz monzonite to granite appear to truncate the foliation in the surrounding gneiss.

A gently southeast-dipping mylonite zone, at least 50 km long and 5 km wide (apparent map width), developed across the gneiss complexes, coincides in part with the northern boundary of the downfaulted block of Double Mer sedimentary rocks, but its formation predated the block faulting.

Map Units

Unit 1 includes granitic and aplitic gneiss. Subunit 1a is a pink to reddish to buff, medium- to coarse-grained, well banded biotite granitic gneiss. It is commonly migmatitic, and includes abundant layers and lenses of amphibolite; where extensive, the amphibolite is differentiated on the map as unit 3. Some amphibolite layers are conformably interbanded and others are crosscutting; thus, it is clear that at least two (and possibly more) protoliths exist. From these characteristics, the amphibolite bodies are interpreted as being in large part relict dykes. Pegmatite veins and dykes truncate the gneissosity and are themselves folded. A sliver of garnetiferous rock composed of coarse grained micaceous amphibolite and fine grained, well layered quartzofeldspathic gneiss interlayered over a few metres, thought to be of supracrustal origin, occurs within the gneiss complex on the shore of Double Mer. It is included in the western exposure of unit 2 on the map. Subunit 1b is a salmon to cream, fine grained aplitic gneiss to microgranite. Rock types intermediate between subunit 1a and 1b "end members" constitute most of the granitic gneiss complex. It appears that units 1 and 2 contain rocks of differing protolith (i.e. metagranitoid, metasediment, mafic dykes, etc.). They may also contain rocks of more than one age, and are likely to have had a prolonged deformation history which includes both Hudsonian and Grenvillian components. Unit 1 is correlated with parts of the granodiorite gneiss terrane to the east (unit 5 of Gower et al., 1981), and is interpreted as an early granitic terrane of pre-Grenvillian age.

Unit 2 is a medium grained, grey or black and white, strongly banded, migmatized biotite tonalitic to granodioritic gneiss. It commonly contains minor garnet, epidote and muscovite. In contrast to unit 1, amphibolite is rare. Enclaves of granitic gneiss, from 1 to 100 m across strike, that are interlayered in unit 2, are included in unit 1 on the map because of broad lithological similarity. However, these enclaves could also be of sedimentary origin, as suggested by the fine grained sillimanite and kyanite tentatively identified in two outcrops, near the eastern and western boundaries of 13F/16 map area; they may be equivalent to distinctive aluminosilicate-bearing gneiss mapped farther west (unit 2 of Ryan et al., 1981). The tonalite gneiss of unit 2 is correlated with similar rocks to the west, for which Ryan et al. (1981; units 1 and 13) propose an Aphebian or earlier age. The relative ages of units 1 and 2 are unknown. On the basis of interdigitation with unit 1, unit 2 is interpreted to be of Helikian or earlier age. Its protolith may have been mostly tonalite or granodiorite, or it may have been sedimentary strata.

Unit 3 includes medium grained amphibolite, amphibolite gneiss and micaceous amphibolite. Both early, partially digested layers and lensoid heterogeneous boudins with nebulitic margins, and later, more homogeneous crosscutting, but folded, dykes can be recognized in the eastern part of the area; similar features characterize the map-scale bodies. Protoliths of unit 3 are considered to be mafic dykes of Aphebian to Grenvillian age.

Unit 4 is dark, dense, medium grained hornblende (and minor pyroxene) dioritic to quartz dioritic gneiss, commonly garnetiferous. It occurs as small, isolated lenses interleaved with units 1 and 2, and is gradational in part to unit 3 (amphibolite). Its age relative to units 1, 2 and 3 is unclear; it may be Aphebian or younger. The unit could represent diorite intrusions into the "basement gneiss" of units 1 and 2, or it may itself be part of the basement complex.

Unit 5 includes distinctive, coarse grained augen (K-feldspar) foliated granitoid rocks and augen gneiss. It is divided into subunit 5a, a pink megacrystic biotite granodiorite that is only moderately foliated, and subunit 5b, a grey augen biotite granite gneiss with a strong foliation. A few nearly rectiplanar crosscutting pegmatite dykes occur near the centre of the orthogneiss bodies; amphibolite layers are rare, and confined mostly to the margins. Unit 5 is interleaved with units 1 and 2, and has sharp contacts. The bodies may be intrusions of Paleohelikian age, emplaced into the older gneiss terrane, and foliated before or during the Grenvillian Orogeny. They are correlated with elongate megacrystic granodiorite bodies occurring to the east (unit 6 of Gower et al., 1981).

Unit 6 comprises coarse grained, pink to buff biotite granite. It occurs as a pluton at least 50 km across in an east-west direction. It is nearly massive in its centre but is strongly foliated at its margins, where it is difficult to distinguish from its gneissic host because of strong boundary deformation. Garnet occurs sparingly in many outcrops. Amphibolite does not occur in the unit. Pending radiometric dating, unit 6 is correlated with granite plutons of similar character occurring to the north (Benedict Mountains Suite, Gower, 1981), that have yielded Paleohelikian K-Ar and Rb-Sr ages (Gower, personal communication, 1982).

Unit 7 is exposed on the south shore of Lake Melville. Subunit 7a comprises dark grey, massive, coarse grained leuconorite and anorthosite. It is part of the Mealy Mountains complex of Paleohelikian age (Emslie, 1982). A small, rectiplanar northeast-striking diabase dyke (subunit 7b) intrudes the anorthosite near Etagaulet Point; it is correlated with the olivine diabase dyke swarm mapped by Emslie (1976), of Elsonian age (Emslie, 1370 Ma age determination, unpublished data; Gittins, 1972).

Unit 8 occurs as three intrusive bodies, each less than 3 km across, that appear to truncate the regional foliation sharply. Subunit 8a is pink, coarse grained, massive to weakly foliated biotite syenite to quartz syenite; subunit 8b is massive, buff, coarse grained biotite quartz monzonite to granite. The northern body of unit 8b contains garnet; in both bodies, quartz is characteristically dark grey to brown. From their generally massive and discordant character, the bodies of unit 8 are interpreted to be of Elsonian or younger age, and show evidence of only weak Grenvillian deformation.

Unit 9 comprises coarse grained, massive metagabbro and hornblendite occurring as a small intrusive body, about 2 km across, that appears to truncate the regional foliation sharply in surrounding rocks of unit 2. Based on this apparent

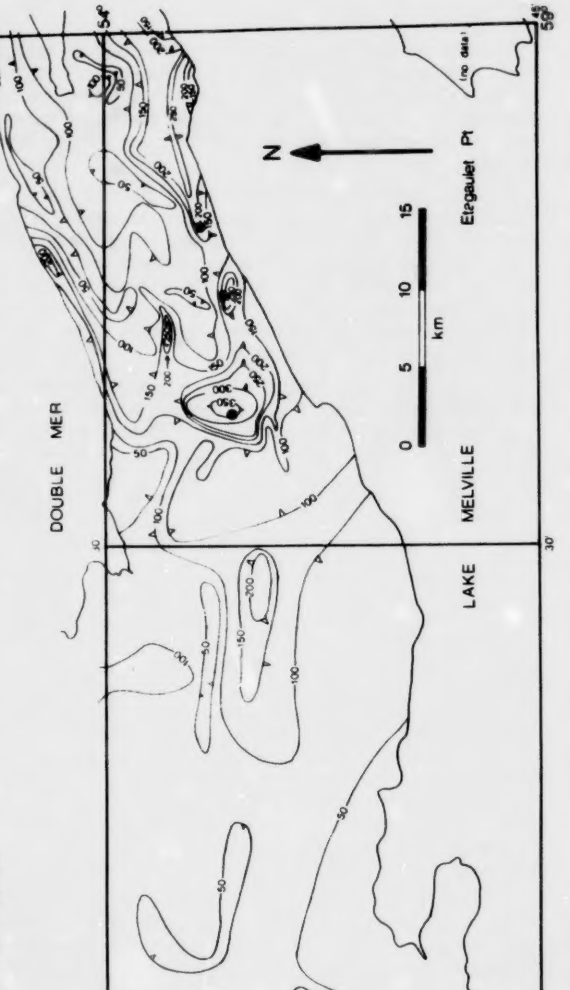


Figure 40.3. *Radioactivity within the map area. Isorads are based on total count per second readings, taken at every geological station during mapping.*

regional truncation and on the low strain in the rocks, unit 9 may be of the same age as unit 8, assuming that strain was homogeneous in this part of the area.

Unit 10 occurs as elongate, discontinuous, lensoid bodies interbanded within unit 1. It comprises chalky white weathering, equigranular, coarse grained, leucocratic quartzofeldspathic rock of migmatitic origin. The largest masses are differentiated on the map, but almost every outcrop of unit 1 in the region where bodies of unit 10 are shown on the map includes amounts of partial melt substantially higher than elsewhere in the area (over 50% is common). These nearly homogeneous masses of diatexite invariably have radioactivity above regional background levels; three uranium showings are known in the area (see below). Gower (personal communication, 1982) identified sillimanite in a thin section of a sample of the unit, cut from drill core obtained by Northgate Exploration Ltd. at the central uranium showing (see Fig. 40.3). Sillimanite-bearing paragneiss has been mapped by Gower et al. (1981) on strike to the east, across Lake Melville, where it is also associated with uranium mineralization; the paragneiss is thought by Gower (personal communication, 1982) to be derived from a pre-Hudsonian protolith. This suggests that the diatexite in the present area may have developed in part from Aphebian or earlier metasedimentary rocks, assuming that strain was heterogeneous in this part of the area. The unit is assumed to be of Neohelikian or Grenvillian age.

Unit 11 is the Double Mer Formation (Kindle, 1924). It is a succession of reddish brown arkosic sandstone and clast-supported polymictic conglomerate of post-Grenvillian age. It occurs as a nearly homoclinal, gently west-dipping sequence, in a lowland bounded on the north by a scarp up to 200 m high. Samples of sandstone from five localities were processed for palynomorphs, but proved to be barren of recognizable microfossils (E. Erdmer, personal communication, 1982). The unit is suspected to be of Hadrynian age.

Structure

The dominant fabric element of units 1 and 2 is a marked gneissosity. In outcrops of unit 1 on the Double Mer Peninsula, this fabric is commonly affected by contorted, irregular, tight folds ranging from 10 cm to over 10 m in amplitude. Highly distorted, local superimposed folding patterns are present in outcrops where the folding is less extreme. Although this folding somewhat obscures regional trends, an east-northeast vertical grain is dominant. In unit 2, open vertical folds inferred on the map suggest an interference pattern of domes and basins, elongated in a northwesterly direction near the western boundary of the area. This style of deformation was recognized farther west by Ryan et al. (1981).

The amphibolite and dioritic gneiss of units 3 and 4 have a foliation parallel to their contacts, and are structurally concordant.

The homogeneity of units 5a and 5b and the fact that the type of surrounding rocks varies suggest that the megacrystic granodiorite and granite are structurally younger, although now nearly structurally concordant.

Notwithstanding its foliated margins, the large pluton of unit 6 is regionally apparently discordant relative to the intruded gneiss. The intrusive rocks of units 8 and 9 are clearly crosscutting from map patterns, and only weakly foliated near their margins.

The mylonite zone in the western half of the area is characterized by strong, shallowly southeast- to south-plunging rodding and mullion structure, flattened and drawn out quartz and feldspar grains visible in hand specimen, and comminuted micas resulting from cataclasis. These features are overprinted by another deformation recorded in epidote coated fractures, chloritic, very fine grained, sheared friable rock and hematite veining. A tentative interpretation is that these later, brittle features resulted from normal faulting at shallow depth associated with, or postdating the deposition of the Double Mer sediments, and that the mylonite was developed previously from "basement" gneiss at considerable depth. The mylonite outlines a zone of high strain interpreted as the trace of a (pre-?) Grenvillian, shallowly southeast-dipping fault that was reactivated by normal faulting.

To the west of the map area, Ryan et al. (1981) recognized a gently southeast-dipping mylonite zone associated with a thrust fault, whose strike extension matches the trace of the present mylonite zone. This suggests continuity of the structure; it is thus likely that mylonite is also associated with thrust faulting north of lake Melville.

Metamorphism

With the exception of the Double Mer Formation, all units in the map area, including the mylonite, are recrystallized. A sugary, friable texture characterizes many of the quartzofeldspathic rocks.

A partial melt phase, in the form of small lenses and strips of quartzofeldspathic material a few centimetres wide, is developed between the folia of most rocks of units 1 and 2. Kyanite and sillimanite have been tentatively identified in slivers of inferred supracrustal gneiss included in unit 2. Unit 1 contains the assemblage quartz-K-feldspar-plagioclase-biotite-hornblende-garnet. The tonalite gneiss of unit 2 contains the assemblage quartz-plagioclase-biotite-muscovite-garnet-epidote; a coarse grained, equigranular rock containing the assemblage quartz-garnet-clinopyroxene-plagioclase is interbanded in unit 2 near the centre of 13F/16 map area. Sillimanite, biotite, quartz and K-feldspar occur in at least one outcrop of diatexite (unit 10); this places the rock above the muscovite "breakdown" curve (with quartz), in the stability field of sillimanite, which implies a minimum temperature of 620°C, and pressure greater than 200 MPa (equilibrium curves after Holdaway, 1971, and Helgeson et al., 1978).

Chlorite, and/or sericite are present in many outcrops as retrograde minerals.

This evidence suggests that metamorphic grade in the crystalline rocks is at upper amphibolite facies, with some retrograde overprinting in the greenschist facies.

Economic Potential

No new surface occurrences of economic minerals were found and, with the exception of uranium in unit 10, the region has attracted little exploration interest.

Recent work by McConnell (1979) determined the presence of anomalous uranium concentrations in lake sediments; uranium mineralization, showing as a yellow uranophane(?) stain on outcrop surfaces, occurs in three localities. Uraninite has been identified as the primary uranium mineral (Kerswill and McConnell, 1982). Northgate Exploration Ltd. carried out exploratory trenching and drilling at the central showing in 1979.

A scintillometer survey carried out during the present mapping reveals that regional radioactivity peaks in the general area of known showings (Fig. 40.3). Although they occur over a wide area, higher total counts are low in absolute terms (a few hundred counts per second); this suggests that mildly uraniferous partial melt (unit 10) is the major source of radioactivity. As this unit occurs over a relatively extensive area, and several other positive anomalies occur, it is possible that additional uranium concentrations exist. On the basis of the occurrence of unit 10 and higher radioactivity, prospective mineralization sites may be located a few kilometres north and east of the known showings, within areas bounded by the 250 counts per second isorads on Figure 40.3.

Summary

The geological infrastructure of the area appears to include the following elements. Two compositionally distinct, heterogeneous, highly deformed gneiss complexes, of possible Aphebian or earlier age, contain remnants of inferred supracrustal origin, whose age is unclear but may be close to that of the gneiss, and younger(?) metaplutonic rocks. The complexes were intruded by a late Hudsonian or early Paleohelikian granite pluton, as well as by Paleohelikian anorthositic rocks and by structurally late plutons of granite to syenite. Northwesterly directed thrusting may be of Grenvillian or Neohelikian age, as inferred by Ryan et al. (1981) for the area to the west. The thrust fault zone was reactivated as a normal fault during or following deposition of the postorogenic Double Mer sediments.

The broad, open folds and shallowly dipping foliation that characterize the western part of the area suggest that the latest deformation was relatively weak; this is in contrast to the marked east-northeast vertical grain in the east, where strain is considerably higher. This suggests either that deformation during the Grenvillian Orogeny was inhomogeneous, or that it was very weak and was superimposed on a heterogeneously (previously) deformed area.

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REGIONAL GEOCHEMICAL SURVEYS

by

P.H. Davenport and A.J. Butler

Newfoundland

Data from the lake sediment geochemical surveys in northwestern Newfoundland, for which the sampling was carried out in 1981, were released on open file on June 24th, 1982 for NTS area 12H and August 31st, 1982 for NTS areas 2L, 2M, 12I and the Newfoundland portion of 12P (Butler and Davenport, 1982a, b). Regional geochemical coverage is now complete for the entire island of Newfoundland outside the Terra Nova and Gros Morne National Parks, as illustrated in Figure 1.

Although the sampling phase of the regional surveys in Newfoundland is complete and the data are available in a preliminary format, work on this project continues on three topics:

1) Data verification. Extensive checking of the field data has been carried out, with particular attention being paid to the UTM coordinates. A 5% random subset of the samples from all survey areas covered since 1973 has been selected and will be reanalyzed for all the elements in the present suite.

2) Compilation of a geochemical atlas. To ensure that the data remain current and readily available they will be recompiled into two atlases. The first will be a 1:1,000,000 summary compilation to illustrate regional features, which could be used in conjunction with the other existing or planned geological and geophysical compilations at this scale. The proposed method of data summarization was described in Davenport (1982a), where some illustrations of the use of this type of compilation were given. A preliminary series of maps similar to that shown in Figure 1 will be available early in 1983. In addition a series of maps at 1:250,000 scale showing all sample site data in relation to the drainage and geology will be produced to provide a permanent display of the data for mineral exploration and resource appraisal purposes.

3) Expansion of the element suite determined on lake sediments. Currently Cu, Pb, Zn, Co, Ni, Ag, Mo, U, F, Mn, Fe and L.O.I. (loss on ignition, a measure of organic carbon content) are determined routinely on lake sediments collected in Newfoundland. More recently Cd has been determined (by atomic absorption), and shows promise for yielding data useful in the search for sulphide deposits. Barium was determined in lake sediments collected over the Carboniferous Codroy - Bay St. George Basin (McArthur *et al.*, 1975). The distribution of Ba in lake sediments also yielded useful results, although only when determined by X.R.F.; atomic absorption was not sufficiently sensitive to yield good precision at the levels encountered in the lake sediments. More recently Sn and W have been determined on test sets of lake sediments over mineralized granites. Over the Sn-mineralized Ackley Granite no response was observed in the lake sediment (Davenport, 1981), but there is a strong response of high W values (greater than 30 g/t) in lake sediments over the W-bearing granites at Granite Lake, Central Newfoundland (Davenport, 1982b). Other areas where the lake sediments are anomalous in W over the Facheux Bay Batholith are shown in Fig. 2, and warrant further follow-up. Elements such as As and Hg in lake sediment have proven useful in other areas, and may be added to the element suite for the lake sediment from Newfoundland. In addition the potential

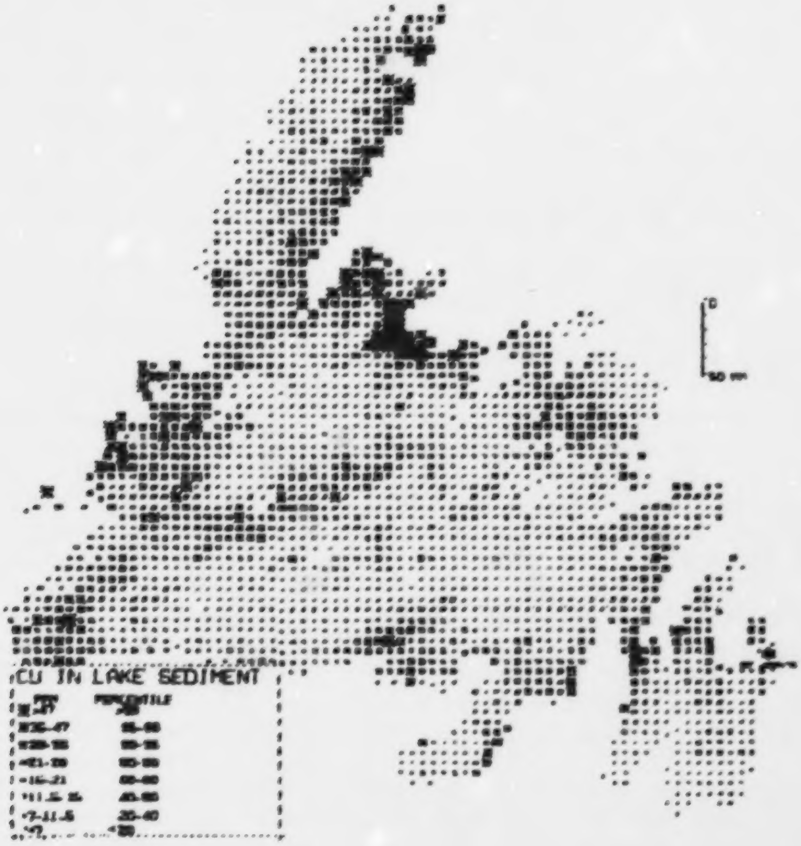

Fig. 1: Compilation map showing the distribution of Cu in lake sediment on the island of Newfoundland.

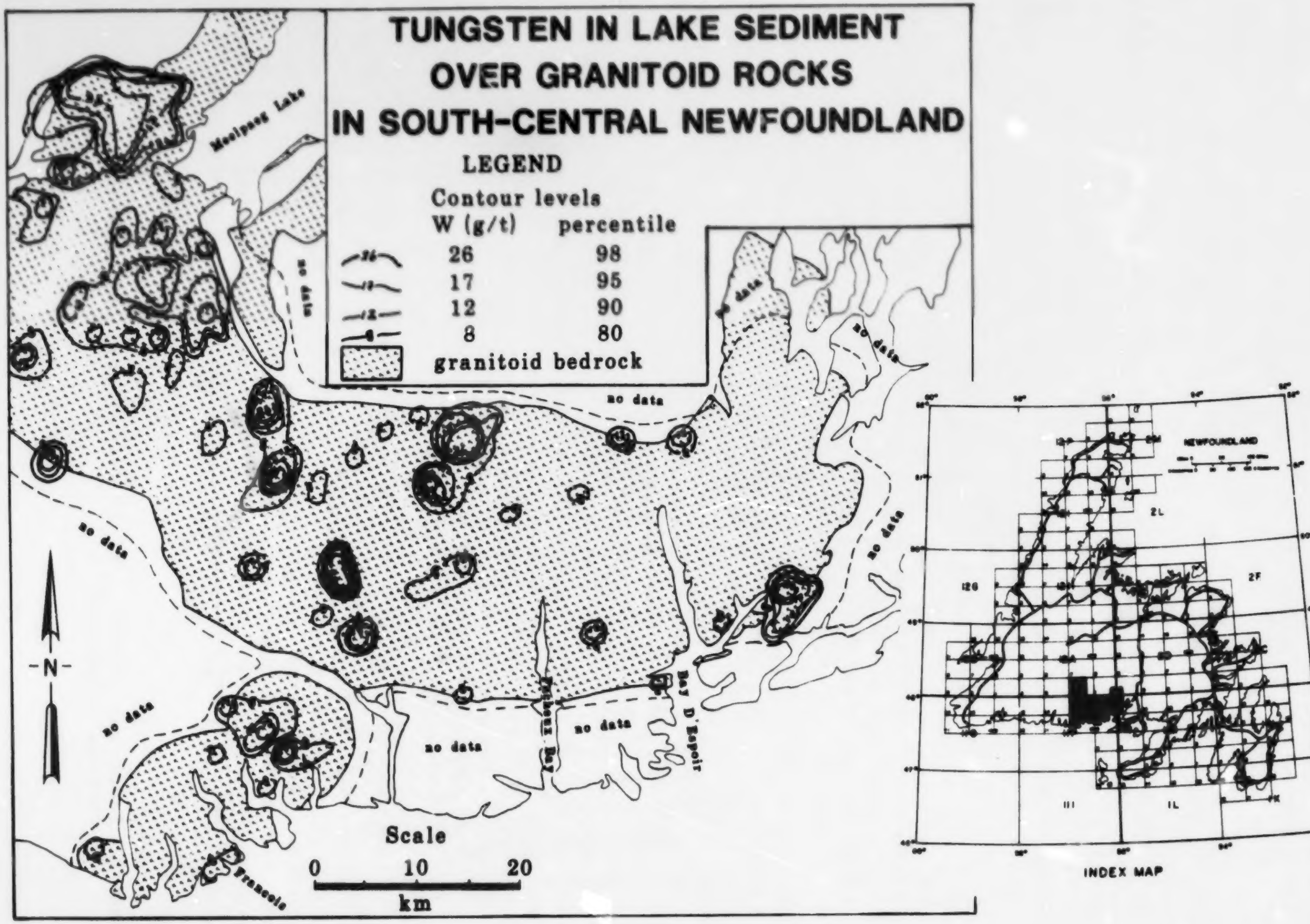

Figure 2. Distribution of W in lake sediment from over granitoid terrain in south-central Newfoundland.

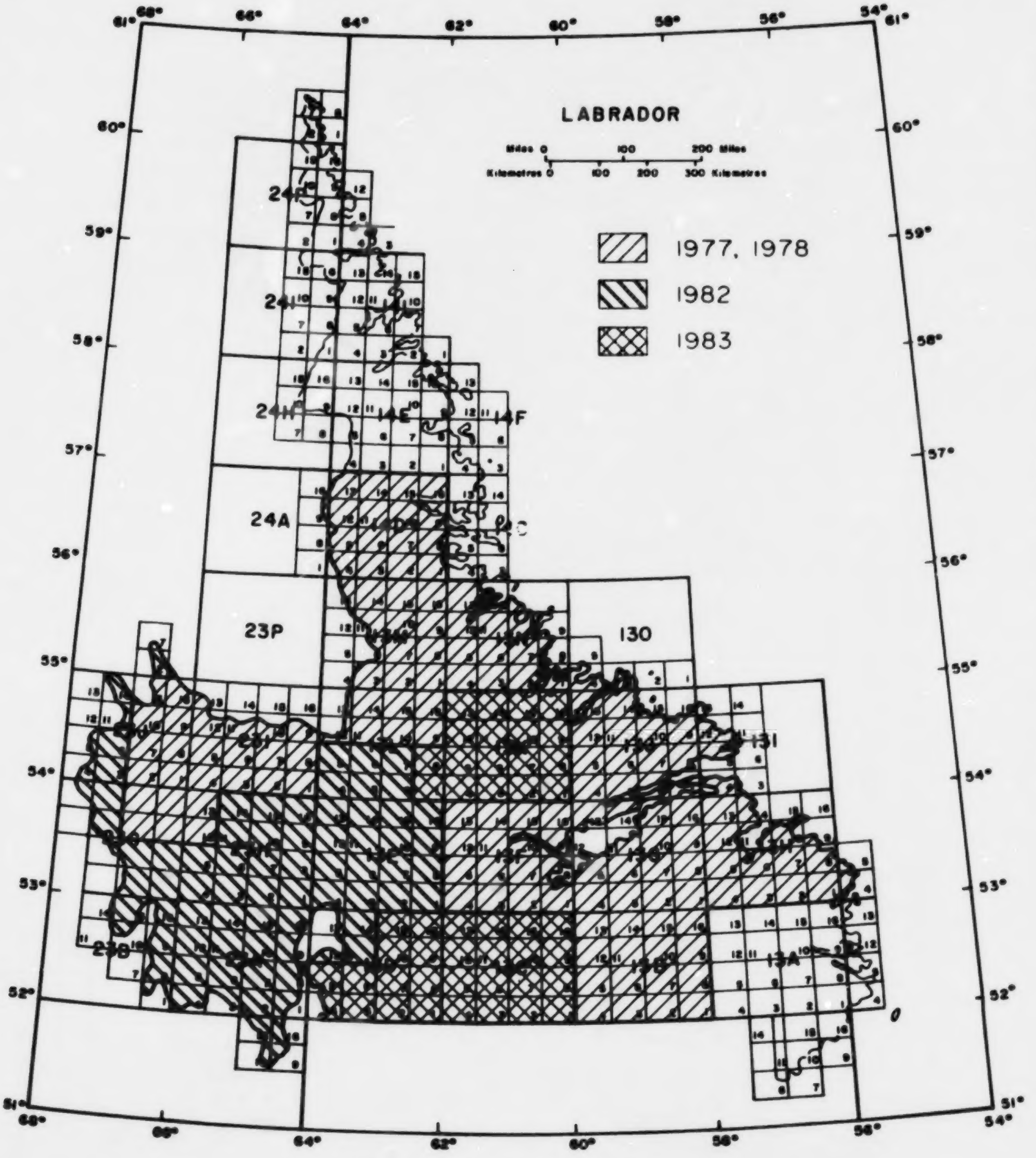

Figure 3. Index map showing the extent of regional geochemical coverage in Labrador.

of lake sediments to reflect bedrock geochemical variations in Li, Be, B, Mg, Ca, Cr, Se, Rb, Sb, Te, Cs, Au, Bi and Th will be investigated over selected geologic targets where significant bedrock variations would be anticipated.

Labrador

The status of regional geochemical coverage of Labrador is shown in Figure 3. The surveys in 1977 and 1978 were carried out under the Canada - Newfoundland Uranium Reconnaissance Programme. This year the Resource Geochemistry Subdivision of the Geological Survey of Canada started to complete the coverage for southwestern Labrador. In July and August, 1982, waters and sediments from lakes over an area of about 50,000 km^2 (Figure 3) were sampled at an average density of 1 sample per 13 km^2, and next year sampling will be completed in 13K, 13C, 13D and 13L. Lake sediment samples from this year's work are currently being prepared and will be analyzed for U, Cu, Pb, Zn, Co, Ni, Ag, Mo, Mn, Fe, F, As, Hg and L.O.I. In addition U, F and pH will be determined on the water samples.

Data from the completed NTS sheets sampled in 1982 will be released on open file next year. All remaining data will be released in 1984, following the preparation and analysis of samples to be collected in 1983.

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SOIL, STREAM AND ROCK GEOCHEMICAL SURVEYS OF THREE NEWFOUNDLAND GRANITOIDS

by

J.W. McConnell

INTRODUCTION

During the summer of 1982, the Geochemistry Section began a study of the geochemistry of surficial material over portions of three granitoid bodies in south-central Newfoundland. The principal aims are to determine optimum geochemical prospecting methodologies for mineral exploration in granites and to further assess the mineral potential of the three granites studied. In addition to surficial material, numerous samples of mineralization, wall rock and unmineralized granite were collected. The three granitoid terrains are located in (1) the Granite Lake area of central Newfoundland, (2) the southern part of the Ackley Granite near Grand Le Pierre, southwestern Newfoundland, and (3) the François area centred 12 km northeast of François on the south coast (see Figure).

The areas were selected on the basis of favorable lake sediment geochemistry and geology. The first two areas have granite-hosted mineralization (W-Mo at Granite Lake and Sn-Mo in the Ackley Granite). The François area has no known mineral occurrences, but it has received very little prospecting attention and no detailed geological information is available.

GRANITE LAKE AREA

This study area is located in the northwestern part of N.T.S. map 12A/2 and occupies about 165 km^2. Access is by gravel road from Millertown, 75 km (3 hours) from the central part of the area.

Relief is moderate and drainage is fair to poor, with considerable bog in low areas. Vegetation density ranges from thickly wooded to sparse.

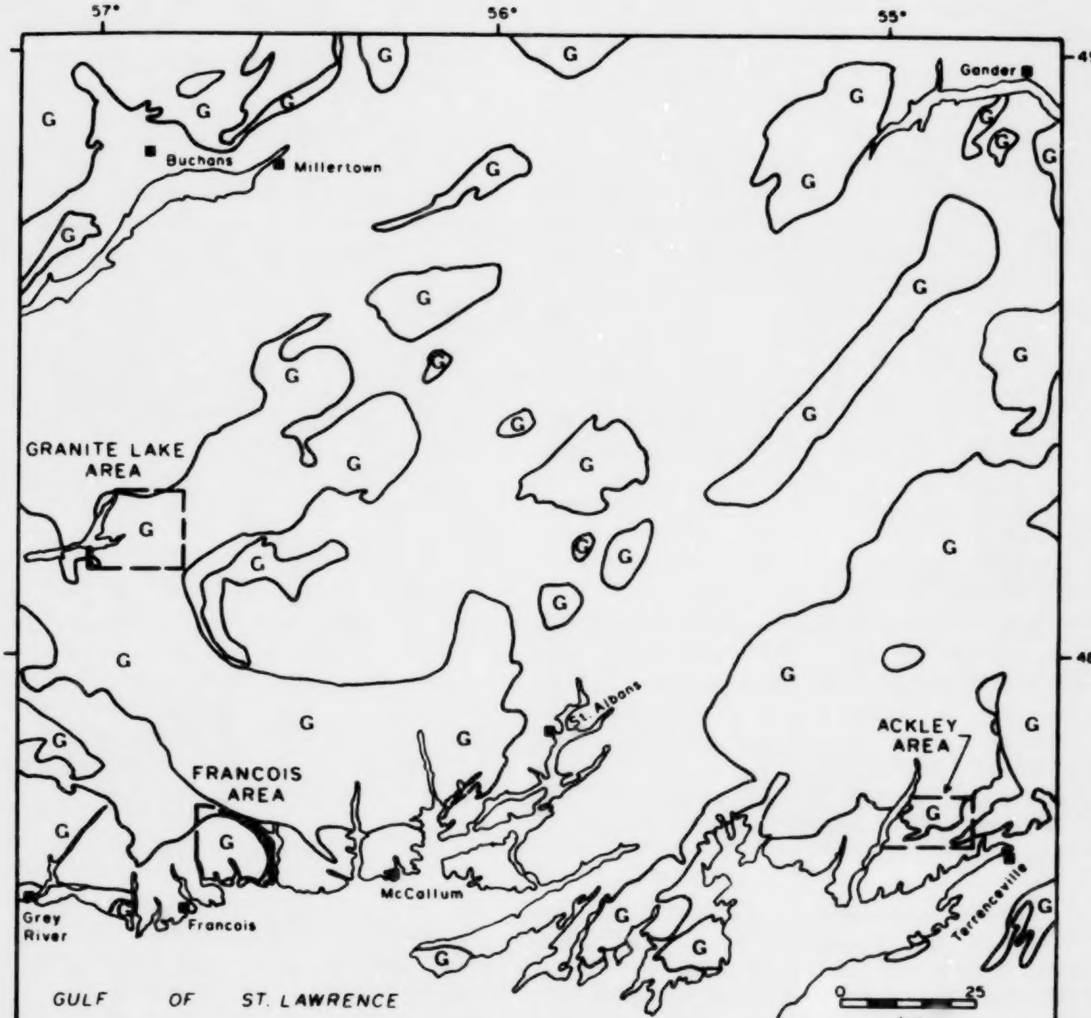
Previous Work

Recent exploration interest in the area stems directly from an open file release of data from a regional lake sediment survey (Butler and Davenport, 1978). The sediments were enriched in several elements, including Mo, Ag and U and, to a lesser extent, Cu, Pb and Zn. The centre of the anomaly was staked immediately by several exploration companies, including Falconbridge Nickel Mines Limited, Noranda Exploration Company Limited, Northgate Exploration Limited, Riocanex Limited, and Teck Explorations Limited. During the following period of active exploration, the discovery of widespread wolframite led to a shift in focus from Mo to W as the principal metal of interest. Exploration methods have relied largely on soil sampling to delineate targets for trenching. The most recent geological mapping in the area is that of Dickson (1981) at 1:50,000 scale.

Bedrock and Glacial Geology

Dickson (1981) recognized four granitoid units in the area. The northeastern region is underlain by a weakly foliated, uniform, medium grained biotite granodiorite and tonalite. A small region in the southeast is underlain by a biotite ± muscovite granite. Most of the remainder is underlain by a pink to red, medium to coarse grained, massive to weakly deformed biotite-muscovite granite, which is locally altered and sheared and cut by quartz veins. In the southern part of the area, this unit is distinguished by an absence of quartz veining, a more buff coloration, and the presence of garnetiferous pegmatites. Molybdenite occurs as disseminations, along fractures, and in quartz veins in the biotite-muscovite granite and in the

Contribution to Canada-Newfoundland co-operative mineral program 1982-84. Project carried out by Newfoundland Department of Mines and Energy.



Location of study areas.

granodiorite. Most of the wolframite is associated with quartz veins cutting the granodiorite. Ages of the granitoids are uncertain but have been postulated by Dickson to be Silurian or Devonian.

No detailed mapping of the glacial deposits has been done. The area is extensively till-covered with little outcrop. Angular cobbles and boulders of local bedrock are common, whereas rounded cobbles and boulders of metasedimentary and metavolcanic rocks similar to those found several kilometres to the north are widespread but form a minor constituent of the till. Consequently, most of the till is believed to have been locally derived. Podzolic soil profiles are generally well developed. Typically, a leached gray or buff A_2 horizon and a reddish orange B horizon overlie a sandy yellow till classified as C horizon. Transport direction of the till is considered to have been generally southerly.

Sampling Approaches

The field program included sampling a variety of surficial, organic and bedrock materials at two scales with the aim of determining how dispersion patterns from W and Mo occurrences could be best identified. Site parameters which might affect or correlate with the chemistry of a sample were recorded on field data forms.

Stream sediments were collected as uniformly as possible over the area. Using a nominal sample spacing of 250 m, 150 samples of sediments were obtained. Active silt was collected where obtainable; otherwise, organic sediment was collected.

Reconnaissance till and soil samples were collected from three east-west lines totalling 30 km. B horizon soils were collected every 500 m. At every second site, separate samples were collected of A_0, A_2, B and C horizons. Bulk samples (3 L) for heavy mineral analysis were also obtained at these alternate sites. Where obtainable, C horizon material was taken; otherwise B horizon material was taken. In total, 60 reconnaissance sites were sampled.

Detailed soil and till sampling was done on small grids over two previously known wolframite occurrences. Multiple samples from each of 50 sites were obtained as described above, as well as several bedrock samples where subcrop had been exposed by trenching. Data from these small surveys should shed light on the nature and extent of dispersion in tills overlying mineralized bedrock.

Analyses

The <180 µm fraction of stream sediment, soil and till samples is being analyzed for W, Cu, Pb, Zn, Ni, Co, Ag, Mn, Fe, Mo, F and L.O.I. Heavy mineral separations of the bulk samples will be made and analyses performed on various size fractions.

Rock samples are being crushed, pulverized, and analyzed for major and minor elements as well as a suite of trace elements including Cu, Pb, Zn, Co, Ni, Ag, F, Mo, Be, Bi, As, Sn, W, Rb, Sr, Ba and Li. A representative portion is being retained in each case for other work if required.

ACKLEY GRANITE AREA

This study area is located in the northwestern portion of NTS map 1M/10 and occupies about 63 km^2. A well maintained gravel road between Grand Le Pierre and English Harbour East comes within 3 km of the southern contact of the granite. A footpath links the road to this area. Maximum relief is over 300 m but, generally, the area has a moderately rolling topography. The almost complete absence of trees and the smooth terrain over the granite make for rapid and pleasant traversing. The volcanic terrain, on the other hand, is characterized by thick vegetation in many areas and by broken, blocky topography, making walking slow and arduous.

Previous Work

Occurrences of molybdenite were known from this part of the Ackley as early as the 1940's. In reports of detailed prospecting in 1953-54 by the American Zinc Company (Ricketts and Bumgarner, 1954) of showings in the Anesty Hill area, the molybdenite occurrences were interpreted to be disseminations in metasedimentary quartzites which form roof pendants in the batholiths. More recent investigators view the quartz-rich rocks as late stage derivatives of igneous activity (Dickson, 1982). Recent exploration activity was sparked by the release of reconnaissance lake sediment data (Butler and Davenport, 1979), which led Esso Minerals to acquire much of the anomalous area. These data showed pronounced enrichment in U, Mo, F, Pb and Zn. Subsequent rock analyses yielded Sn values as high as 221 g/t (Dickson, 1982).

Bedrock and Glacial Geology

Most of the area is underlain by the Ackley Granite. A fine grained border phase of the granite in contact with the sedimentary and volcanic rocks to the south was recognized by Dickson (1982). Up to 4 km wide, this phase differs from the predominant phase of medium to coarse grained biotite granite found to the north. Dickson considered the presence of miarolitic cavities and granophyric textures to be evidence of high level emplacement.

The area is covered by a thin mantle of glacial drift. The till is generally composed of poorly sorted sand and pebbles, with a few areas underlain by well sorted, presumably waterlaid sands. Soil profiles are generally poorly developed and B horizons are often not clearly distinguishable. Glacial striae trending due north-south were observed on one outcrop of polished quartzolite. Vanderveer (1982) reports that glacial transport was generally toward the south but the distance of transport is unknown.

Sampling Approaches

Emphasis in this area was placed on obtaining bulk (5 L) till samples for both regular and heavy mineral analysis. Accordingly, samples were collected at 400 m intervals along three lines each 13 km long. These east-west lines were spaced 1 km apart and extended into volcanic/sedimentary terrain at each end. Similar samples were collected at closer intervals (250 m) along 22 km of granite/volcanic rock contact. Since most of the quartzolites observed were very close to the contact but within the granite, till samples from this line were collected over the granite but usually within 50 m of the contact. In addition, bulk till samples were collected at 1 km intervals along a 13 km line in the volcanic rocks; the samples were located about 500 m, on average, south of the granite/volcanic rock contact. Detailed bulk till/soil sampling was done over two small grids located over quartzolites known to carry Sn mineralization.

In total, 252 bulk samples and 245 normal size samples were collected. As well, 24 bedrock samples of quartzolite, granite and volcanic rocks were obtained.

Analyses

Analyses of soils, tills and rocks will be made in a similar manner to that described previously for the Granite Lake area. In addition, Sn will be analyzed.

FRANCOIS AREA

This study area occupies about 110 km^2 in the eastern half of N.T.S. map 11P/10. A seven-man camp was established in the central part and almost all regions could then be reached by foot traverses. Access to the area was by CN coastal boat from Terrenceville to McCallum and, thence, by longliner for an additional 37 km along the coast. A helicopter was used to move material and personnel the final 5 km to camp.

Although the maximum relief is about 430 m, most of the area forms a plateau at an elevation of about 300 m which falls abruptly to sea level at the southern boundary and along the numerous fiords which dissect the area.

Outcrop is abundant (approximately 30%) and the remaining surface is covered by a thin veneer of till and vegetation.

Previous Work

There is little information published regarding detailed geological mapping or mineral exploration. Williams' (1971) 1:250,000 scale geological map shows the area to be underlain by Devonian granite lithologically similar to the large arcuate North Bay batholith to the north. Regional lake sediment data (Butler and Davenport, 1978), however, show the follow-up area to have a distinctly different geochemical response from most of the northern granitic terrain. Very high values of Pb and high U, Mo and F values are prevalent, suggesting that this granitoid is highly differentiated and enriched in elements characteristic of mineralized granites. Possible types of mineralization might include Sn, W, Mo, U and Be.

Bedrock and Glacial Geology

The bedrock of the area has been mapped only at a reconnaissance scale and the glacial deposits not at all. Although we made no attempt to map the area, a few observations might be pertinent.

Generally, the rock is a pink quartz-feldspar-biotite granite. Grain size varies from medium to very coarse. Large K-feldspar phenocrysts are common. The rock is massive except near a major northwesterly striking mylonite zone. Quartz-veining and hematite-staining are common there but scarce elsewhere. Aplite dikes are quite abundant throughout; they locally contain quartz veins and, in one instance, minor molybdenite. The only other evidence of mineralization noted was coarse grained, white to pale blue and green beryl crystals found in a talus slope. The source was not located but presumably lay upslope. Limited spectrometer surveying indicated that the granite is approximately twice as radioactive as an average granite.

Toward the sea, bedrock exposure approaches 60-70 percent. Inland, the till veneer progressively thickens and becomes more extensive.

Sampling Approaches

The scarcity of soil restricted its use as a sampling medium. Streams are numerous, however, and active sediment surprisingly abundant despite the relief and barren nature of the landscape. The granite, both here and at Granite Lake, seems to weather rapidly, as evidenced by skirts of quartz and feldspar crystals on the ground surrounding isolated boulders. One problem encountered was that of obtaining sufficient fine material for an adequate <180 µm fraction. In a few instances, two bags of sediment were collected to ensure an adequate sample. In the laboratory, it was found that a mechanical sieve shaker would usually yield sufficient material whereas hand sieving frequently would not.

Altogether 156 stream sediment samples were collected at a sampling interval of 300 m. Forty-three rock samples were also collected.

Analyses

Analyses of stream sediments and rocks are being done as described above for Granite Lake. Tin in sediments is also being analyzed. No heavy mineral separations are planned.

DATA RELEASE

It is expected that a preliminary open file release of data for the three areas will be made during the winter of 1983.

ACKNOWLEDGEMENTS

The successful completion of the seven-week field season was due in large measure to the diligence and resourcefulness of six earth science students from Memorial University, namely, Gerry Whalen, Lorna King, Peter King, Lorraine Mitchelmore, Tony Walsh and Mike Wawrzkow. Each is thanked for his or her contribution to what proved to be a productive and enjoyable summer. Wayne Ryder, Sid Parsons and Jim Barrett are thanked for their logistical support. Frank Blackwood and Morris West extended their hospitality to our large party on very short notice on two occasions for which I am grateful.

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COMPUTER UNIT

by

H. Missan

The primary objective of the Computer Unit is to help meet the data processing needs of the scientific staff of the Mineral Development Division. The unit is developing computer-supported systems for the compilation and management of resource data (lake sediment geochemistry, metallogeny, lithogeochemistry) collected by project geologists. This will ensure ready access to the data by provincial and federal government agencies and mineral exploration companies. The machine used for the Division's computing needs is the Amdahl V/6 installed at the Computer Resource Center at Higgins Line. Access to the computer is provided through the use of three high speed terminals, a graphics terminal and a dial-up terminal.

The main types of data that have been collected by geologists and are stored on the computer are from projects in the following areas:

i) lake sediment geochemistry

ii) stream sediment geochemistry

iii) water geochemistry

iv) lithogeochemistry

v) mineral deposit studies

vi) surficial aggregate resource evaluation

A number of computer programs are available to geologists for storing, manipulating and displaying data. These programs include: SPSS, SAS, GRASP, SIR. In addition, plotting programs are used for the graphic display of data, *e.g.*, plots of Harker variation diagrams, plots of the spatial distribution of mineral occurrences within a given area, plots of ternary diagrams, etc.

Future plans include:

i) the use of contouring programs for displaying spatially distributed data (*e.g.* geochemical data).

ii) the digitizing of geology maps in order to provide an integrated approach for displaying resource data, *e.g.*, displaying certain geological environments with associated mineralization and geochemical anomalies.

iii) the development of "user-friendly" computer programs for use by geologists in maintaining and manipulating earth science data.

GEOCHEMICAL LABORATORY

by

H.A. Wagenbauer, C.A. Riley and G. Dawe

INTRODUCTION

The laboratory has been reorganized this year as a single unit which includes the assay laboratory and the routine analysis laboratory. Six permanent staff are employed, and the laboratory handles all data preparation, and about 80% of the chemical analyses for the Mineral Development Division. In addition the laboratory arranges for external analytical contracts where necessary.

The laboratory, which is located on Higgins Line in St. John's, is equipped with two atomic absorption spectrophotometers, one spectrophotometer, three infra-red analyzers, a fluorometer, and a digital specific ion meter. Sample preparation equipment includes a tungsten carbide shatter box, disc-mill with ceramic plates, two jaw crushers, an automatic sieve-shaker, and four drying ovens.

At present the lab is routinely performing the following analyses:

1) Major oxides on rocks: SiO_2, Al_2O_3, Fe_2O_3, FeO, MgO, CaO, Na_2O, K_2O, TiO_2, MnO, P_2O_5, LOI, S (total), CO_2 and $H_2^{+}O$;

2) Trace elements on rocks: Ba, Sr, Rb, Cu, Pb, Zn, Ni, Cr, Co, V, Cd, Ag, Mo, Li and Be;

3) Chemistry of lake sediments, stream sediments, soils and tills: Cu, Pb, Zn, Co, Ni, Ag, Mo, Mn, Fe, Cd and LOI;

4) Single element determinations on a variety of materials: F, W and Sn.

In addition there are currently two contracts with commercial laboratories, one for U determinations on a variety of materials by neutron activation/delayed neutron counting, and the second for determination of a variety of trace elements such as Zr, Y, Nb, Th, Ga, Ce and La on rocks by X.R.F., as these elements cannot be determined adequately using the equipment at present available in the lab.

Analytical quality of both internal and external analyses is monitored constantly by the inclusion of blind duplicate and control samples in every batch. The blind duplicate samples are introduced at the sample preparation stage, and the controls are inserted when the samples are weighed for digestion. Control samples consist of both international references materials where these are suitable and available, and internally prepared bulk samples to allow the monitoring of batch to batch variations. Quality criteria for precision and accuracy are established with reference to both the tolerance necessary to solve a particular geochemical problem, and what is practical for the analytical method being employed to allow reasonable productivity. Where data fail to meet the established criteria of precision or accuracy, the determinations are repeated.

DESCRIPTIONS OF ANALYTICAL PROCEDURES

1. The routine determination of major constituents of silicate rocks

A 0.1 g portion of sample is fused in a 9 mL graphite crucible with 0.5 g of lithium metaborate at 1000°C. The hot melt is poured into a 250 mL polycarbonate bottle containing 25 mL of 4 vol % HCl and 5 mL of concentrated HF, and digested at 90°C for 1.5 hours. After the contents are cooled to room temperature, 50 mL of 50 g/L boric acid is added to complex the excess HF and the sample is digested again at 90°C for 1.5 hours. The solution is transferred into a 100 mL polyethylene volumetric flask, made to volume and mixed.

The oxides SiO_2, Al_2O_3, total iron as Fe_2O_3, MgO, CaO, Na_2O, TiO_2 and MnO are determined by atomic absorption spectroscopy, following the methods of Langmyhr and Paus (1968), Abbey (1968), and Buckley and Cranston (1971).

Phosphorus is determined spectrophotometrically on an aliquot of the solution from the fluoroboric acid digestion by reducing the yellow phospho-molybdate complex to the molybdenum blue complex with hydrazine sulphate (Riley, 1958; Hounslow and Moore, 1966).

Ferrous iron is determined on a separate portion of sample decomposed at room temperature in an HF solution containing a known amount of quinquivalent Vanadium, which oxidizes the ferrous iron as it passes into solution. After decomposition is complete the excess V^{+5} is reduced by a known quantity of ferrous ammonium sulphate, the excess ferrous iron being titrated with standard potassium dichromate using barium diphenylamine sulphonate as indicator. Boric acid is used to complex the HF, and H_3PO_4 the ferric iron (Wilson, 1955, 1960; Hounslow and Moore, 1966).

Loss on Ignition is determined at 1000°C by the method outlined by Hillebrand *et al.* (1953).

2. Sulphur, carbon dioxide and water of crystallization in silicate rocks

An infra-red method as developed by Bouvier and Abbey (1980) is used to determine simultaneously S, CO_2 and H_2O^+ in rock samples. Briefly the procedure is as follows:

A 0.2 g portion of sample is weighed into a nickel boat and fused at 950°C with a 1.0 g mixture of equal parts Vanadium Pentoxide and Tungstic Anhydride. The evolved gases are carried in a dry nitrogen stream through a Beckman Model 865 infrared analyzer to determine the water present, and then on to two Beckman Model 864 infrared analyzers to determine the sulphur and carbon dioxide respectively. Each of the constituents of interest gives a millivolt reading on a three channel digital integrator, and this reading is converted to per cent concentration by comparison with known standards.

3. Trace elements in silicate rocks

To 1 g of sample in a 100 mL Teflon beaker are added 15 mL of concentrated HF, 5 mL of concentrated HCl and 5 mL of 50 vol % $HClO_4$. The sample is allowed to stand in the acid mixture overnight, and is then heated to dryness on a hot plate. The residue is taken up in 10 vol % HCl by gently heating on a hot plate. When cool the solution is made up to 50 mL with 10 vol % HCl. The elements Rb, Cu, Pb, Zn, Ni, Cr, Co, V, Mo, Li and Be are determined directly on this solution by atomic absorption spectroscopy. For Ba and Sr a 5 mL aliquot of the solution is transferred to a 25 mL volumetric flask to which 5 mL of a 5% La^{3+} solution and 6.5 mL of concentrated HCl are added. The solution is made up to 25 mL with deionized water, and Ba and Sr are determined by atomic absorption spectroscopy.

4. Lake sediment, stream sediment, soil and till

The Cu, Pb, Zn, Co, Ni, Cd, Mn, Fe, Mo and Ag content of drainage sediment, soil and till are determined by atomic absorption spectroscopy. Four different digestions are used depending on the sample type and element to be determined.

4.1 Cu, Pb, Zn, Co, Ni, Cd, Ag, Mn and Fe in lake sediment. To 1 g of sample in a glass test tube is added 6 mL of 4 M HNO_3 - 1 M HCl, and the mixture is allowed to stand overnight. The sample is then mixed, digested for 2 hours in a water bath at 90°C, mixed again and allowed to cool. The leach solution is made up to 20 mL with deionized water, mixed, and allowed to clear. The elements are determined by atomic absorption spectroscopy using an air-acetylene flame, and automatic simultaneous background correction using a deuterium lamp is employed for Pb, Co, Ni, Ag and Cd.

4.2 Cu, Pb, Zn, Co, Ni, Cd, Mn and Fe in stream sediment, soil and till. The procedure used is as described for lake sediments, except for a slightly different digestion method. Initially 3 mL of concentrated HNO_3 is added to 1 g of the sample in a test tube and allowed to stand overnight at room temperature. The tube is then placed in a water bath at 90°C for 30 minutes, following which 1 mL of concentrated HCl is added and the tube returned to the water bath for a further 90 minutes. When cool, the leach solution is made up to 20 mL with deionized water.

4.3 Silver in rock, stream sediment, soil and till. A separate digestion is used for Ag in these media as the concentration of HCl in the digestion described in 4.2 above causes Ag to precipitate as the chloride. A 2 mL aliquot of concentrated HNO_3 is added to 0.5 g of sample in a 10 mL test tube. The sample is allowed to digest overnight at room temperature, followed by a two hour digestion at 90°C in a water bath. When cool, the solution is made up to 10 mL with deionized water and mixed. The Ag content is determined by atomic absorption spectrophotometry, using an air-acetylene flame.

4.4 Molybdenum in lake and stream sediments, soil and till. A 0.5 g portion of sample is leached overnight in a test tube at room temperature with 1.5 mL of concentrated HNO_3, and then heated in a water bath at 90°C for 30 minutes. A 0.5 mL aliquot of concentrated HCl is added and the test tube returned to the water bath for a further 90 minutes. The tube is allowed to cool and the leach solution made up to 10 mL with 8 mL of a 1250 g/t Al^{3+} solution. The Mo content of the solution is determined by atomic absorption spectroscopy, using a nitrous oxide-acetylene flame.

5. Miscellaneous single element determinations on rocks, drainage sediments, soils and tills

5.1 Tin. A 0.5 g portion of sample is fused with 2.5 g of lithium metaborate in a 9 mL graphite crucible at 1000°C for 1 hour. The hot melt is poured into a Teflon beaker containing 50 mL of 10 vol % HCl. The melt is digested on a hot plate at 40°C overnight. The temperature is increased to 100°C and the digestion continued for 2 hours.

The contents are transferred into a 100 mL volumetric flask, diluted to volume with 10 vol % HCl and mixed. The Sn is determined by hydride generation on an atomic absorption spectrophotometer.

5.2 Tungsten. This colorimetric method is used for determining W in rock, soil, till, stream sediment and lake sediment. The procedure, which is based on those described by Aruscavage and Campbell (1978) and Terashima (1980), is as follows.

To 0.5 g of sample in 100 mL Teflon beaker are added 2 mL of 2% Fe solution, 2 mL of concentrated $HClO_4$ and 10 mL concentrated HF, and the sample is allowed to stand overnight. The sample is taken to dryness on a hot plate at 200°C. When cool, 1 mL of water is added to loosen the residue which is then dissolved in a 30% $SnCl_2$ solution at 100°C on the hot plate and transferred to a stoppered test tube. The test tube is placed in a 90°C water bath for 15 minutes, following which 2 mL of 1% Zn dithiol solution is added, the sample mixed and returned to the bath for a further 30 minutes. The resulting complex is extracted with 5 mL of petroleum ether and the absorbance read at 630 nm on a spectrophotometer. The absorbance is compared with those of chemical standards which are prepared in the same manner as the samples.

5.3 Fluorine in rocks, drainage sediments, soil and till. A 0.25 g portion of sample is mixed with 1 g of a 2:1::Na_2CO_3:KNO_3 flux and fused for 10 minutes in a nickel crucible over a Fisher burner. The residue is dissolved in deionized water and transferred to 100 mL polyethylene beakers. A 10 mL aliquot of 10% citric acid solution and 1 mL of 10 g/t fluoride solution is added, and the solution made up to 100 mL with deionized water. The fluoride concentration is measured using fluoride-ion specific electrodes and a digital ionanalyser, and the fluorine concentration estimated by comparison with standards.

CONCLUSION

The number and types of analyses performed in the laboratory in the 12 month period between September 1, 1981 and August 31, 1982 are given in Table 1. In summary, about 3500 drainage sediment samples were analysed for 11 elements and loss on ignition, 2200 rocks were analysed for 11 major oxides, loss on ignition and an average of 10 trace elements, and, for about 1350 rocks, S, CO_2 and H_2^+O were determined. Single element analyses on a variety of sample types included 1432 for W, 550 for Sn and nearly 10,000 for F. Altogether, over 100,000 determinations were carried out last year.

To meet future demand, which is for a greater variety of elements on a slightly smaller volume of samples, it will be necessary to purchase additional equipment. An inductively coupled plasma spectrometer is being considered to meet the changing work load, and if acquired, the proportion of analyses being sent to outside laboratories would be further reduced.

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TABLE 1. Output from the geochemical laboratory of the Mineral Development Division from September 1, 1981 to August 31, 1982

	Samples Digested	Number of Determinations
DRAINAGE SEDIMENTS, SOIL, TILL		
Cu, Pb, Zn, Co, Ni, Mn, Fe, Ag, Cd	3,760	33,727
Mo	3,213	3,213
Loss on Ignition	3,701	3,701
SILICATE ROCK ANALYSIS		
Trace elements		
Cu, Pb, Zn, Co, Ni, Ba, Sr, Rb, Cr, V, Ag, Be, Li, Mo, Cd	2,119	22,205
Major oxides		
SiO_2, Al_2O_3, Total Iron as Fe_2O_3, MgO, CaO, Na_2O, K_2O, TiO_2, MnO	2,217	19,953
P_2O_5	2,217	2,217
FeO	1,139	1,139
Loss on Ignition	1,626	1,626
H_2^+O, S and CO_2	1,344	4,032
MISCELLANCEOUS SAMPLE TYPES		
Fluorine	9,786	9,786
Tungsten	1,432	1,432
Tin	550	550
	TOTAL	103,581

MINERAL POTENTIAL OF CLASTIC SEDIMENTARY BASINS IN NEWFOUNDLAND

by

P.L. Dean and J.R. Meyer

INTRODUCTION

An evaluation of the potential for sedimentary, clastic-hosted base metal sulphide deposits in Newfoundland continued during the summer of 1982. The emphasis switched from detailed section work (Dean and Meyer, 1982) to a regional stream sampling and prospecting program with concentration in areas with anomalous lake sediment geochemistry. Three main areas of interest were outlined: (1) the Southeast Avalon Peninsula, an area located northwest of Route 10 between Capahayden and Portugal Cove South and underlain by the Hadrynian Drook Formation of the Conception Group; (2) the Northwest Avalon Peninsula, an area due west of Carbonear which is underlain by the Hadrynian Carbonear Formation of the Hodgewater Group, and (3) Humber Arm North, an area northwest of Corner Brook which is underlain by the highly deformed Cambrian clastics of the Humber Arm Allochthon (Fig. 1, 2 and 3). In addition to stream sampling, three sections were mapped and sampled in detail, one from each area on the Avalon Peninsula and the third in the Anguille Mountains, immediately north of the Codroy Valley. General prospecting of quartz veins, mineralized outcrop and float was conducted while silt sampling. Chip samples of shale also were collected where possible. The silt samples are being analyzed for Zn, Pb, Ni, Cu, Co, Mn, Fe, Ag, Cd, and L.O.I.

Southeast Avalon

Lake sediment geochemistry of the southeastern Avalon Peninsula indicates Pb, Zn, Co and Ag anomalies northwest of Route 10 in the Chance Cove Brook and Portugal Cove Brook watersheds (Davenport *et al.*, 1975; Butler and Davenport, 1979). A follow-up stream sediment sampling program was carried out over the barren landscape. The program faced formidable sampling conditions in the area due to the harsh climate and low relief which inhibit silt and soil development. The original plan of 300 m spacing of samples was severely constrained and not always possible. Special effort was made in areas having anomalous lake sediment geochemistry, above and below brook junctions, and where brooks entered ponds or steadies. A total of 166 silt samples were collected and are presently undergoing the 9-element analysis.

The Southeast Avalon Peninsula is underlain by Hadrynian rocks which were mapped by Williams and King (1979). The oldest rocks exposed consist of bimodal volcanics of the Harbour Main Group which form hills and ridges north of Chance Cove Brook. Overlying the volcanics, with local disconformity, is the Conception Group. The Drook Formation is the most extensive formation of this Group and underlies 90% of the sampled area. Outcrop consists of white weathering green siliceous argillites, siltstones and sandstones which exhibit graded sequences over 0.5-1.5 m. White angular feldspar grains and the highly siliceous nature of the sediments suggest a reworked volcaniclastic origin. The Drook Formation is intruded by fine to medium grained Whalesback Gabbro, exposed as rounded hills in the Chance Cove Brook watershed.

Overlying the Conception Group is a sandstone-shale sequence, the St. John's Group, and younger, mainly terrestrial clastics of the Signal Hill Group. The

Contribution to Canada-Newfoundland co-operative mineral program 1982-84. Project carried out by Newfoundland Department of Mines and Energy.

two groups, exposed in a 6 to 7 km wide monocline which is parallel to the coast, are conformable with the Conception Group in the north, but juxtapose it at the Frenchman's Cove Fault in the south. The St. John's and Signal Hill Groups record the shoaling up of the Conception marine basin and southward progradation of a delta front, respectively.

Visible mineralization in the Drook Formation consists of well formed crystals of pyrite within the coarse clastics and 1-5 mm aggregates of sugary textured pyrite + chalcopyrite and pyrrhotite in the fine grained clastics. Chalcopyrite and galena mineralization is hosted within quartz veins intruding the Drook Formation, and in large angular quartz boulders in the sampled area. This may prove to be the source of the lake sediment anomalies and may be more viable exploration targets for base and precious metals. Fifteen chip samples of quartz were collected across the area for analysis for Cu, Pb, Zn, Ag, Au, W and Sn.

North of the sample area, between Fermeuse and Renews Harbours, anomalous Zn and associated Cu and Pb values showed up in the 1975 lake sediment geochemical survey (Davenport *et al.*, 1975). The area is underlain by the Fermeuse Formation, the thickest and most extensively exposed formation of the St. John's Group. The Fermeuse Formation consists of light to dark gray shales with lenticular intercalations of fine grained sandstone in its stratigraphically higher sections. Disseminated pyrrhotite (+ chalcopyrite) was discovered in the shales on the south side of Fermeuse Harbour. A 75 m section of middle to upper Fermeuse Formation was mapped and sampled in detail north of Fermeuse Harbour at Clears Cove. Samples will be analyzed for the same elements as were the Caradocian shales of Central Newfoundland (Dean and Meyer, 1982), facilitating comparisons and further shale studies on the island.

Northwest Avalon

A regional Zn anomaly over the Carbonear Peninsula was outlined by a lake sediment geochemical survey of the Central Avalon Peninsula (Butler and Davenport, 1979). A smaller work area was delineated within the regional anomaly using the highest Zn values, and associated Pb and Ag values. This anomalous zone corresponds with the outcrop expression of the Carbonear Formation according to a geological compilation by King (1980).

The topography of the sample area is rugged, with low to moderate relief. In the southern half, forest, bogs and ponds dominate the lowlands and contrasted with dry rocky uplands. The northern half is largely barrens and burnover. Silt sampling was difficult and time consuming due to the poor silt development along the small brooks which connect the boggy lowlands. A total of 76 silt samples were collected from the work area.

The sampled area is underlain by the Carbonear Formation, the lower unit of the Hadrynian Hodgewater Group. It conformably overlies the Conception Group which outcrops in a small north trending, doubly plunging anticline at the center of the work area. The folding was thought to be Precambrian in age by Hutchinson (1953) but more recent work indicates the main orogenic event on the Avalon Peninsula to be Acadian (O'Brien and King, 1982). This event is probably responsible for the gentle folding on the Carbonear Peninsula, as well as the strong subvertical, north trending cleavage that is pervasive throughout the work area.

The Carbonear Formation consists of variably interbedded and laminated fine grained sandstone, siltstone and shale. Gray siltstone and fine grained sandstone are dominant, and contain dark gray to black shaley or silty laminations. The laminations are

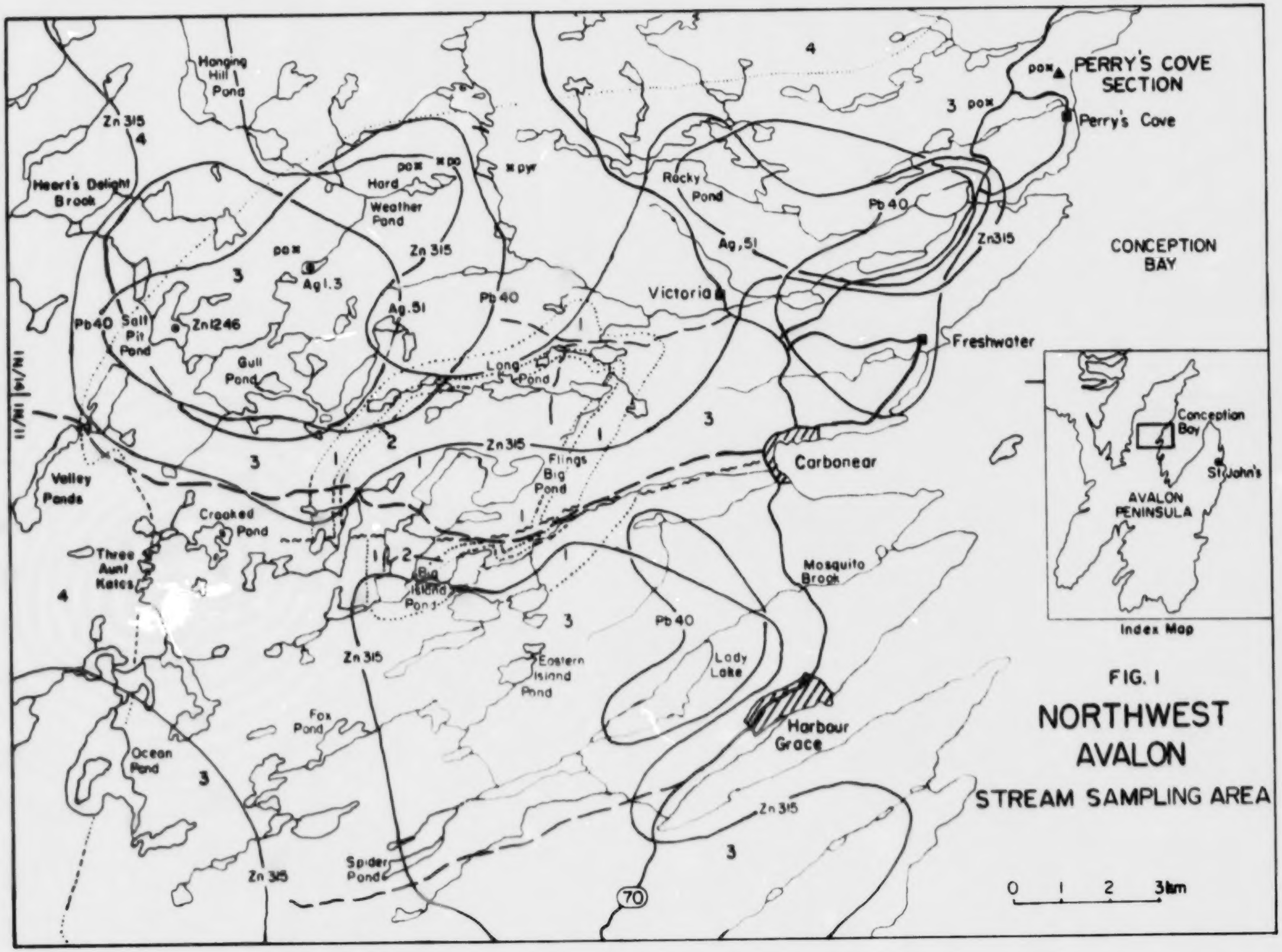


FIG. 1
NORTHWEST AVALON
STREAM SAMPLING AREA

LEGEND FOR NORTHWEST AVALON

HADRYNIAN

HODGEWATER GROUP

4 **HALLS TOWN FORMATION:** massive, green, quartzitic sandstone, siltstone and silty slate, with minor red slate and siltstone.

3 **CARBONEAR FORMATION:** gray to black slate and siltstone in the lower part, with continuous to discontinuous and lensoid, black shaly and silty laminations and stringers. The siltstones increase in number and thickness, and grade into sandstones in the upper part of the formation.

CONCEPTION GROUP

2 HIBBS HOLE FORMATION: well-bedded, strongly cleaved, red slates, with some massive beds, and minor red siltstone; green beds of the same lithology occur locally.

1 DROOK FORMATION: green to greenish gray argillite or argillaceous siltstone, sandstone, cherty beds - especially near the base, and a coarse green basal conglomerate.

Geology from: GSC Memoir 275 by Hutchinson, 1953; GSC Memoir 341 by McCartney, 1967; and I.G.C.P. project 27, Memoir No. 2 by King, 1980.

Lake Sediment Geochemistry from Mineral Development Division, Open File Release: NFLD 1003, by Butler & Davenport, 1979.

KEY FOR FIGURES 1, 2, AND 3

pyrite	pyr
pyrrhotite	po
chalcopyrite	cp
galena	gn

Lake sediment metal values and geochemical contours in parts per million Zn 315

zinc	Zn
lead	Pb
silver	Ag
cobalt	Co
copper	Cu

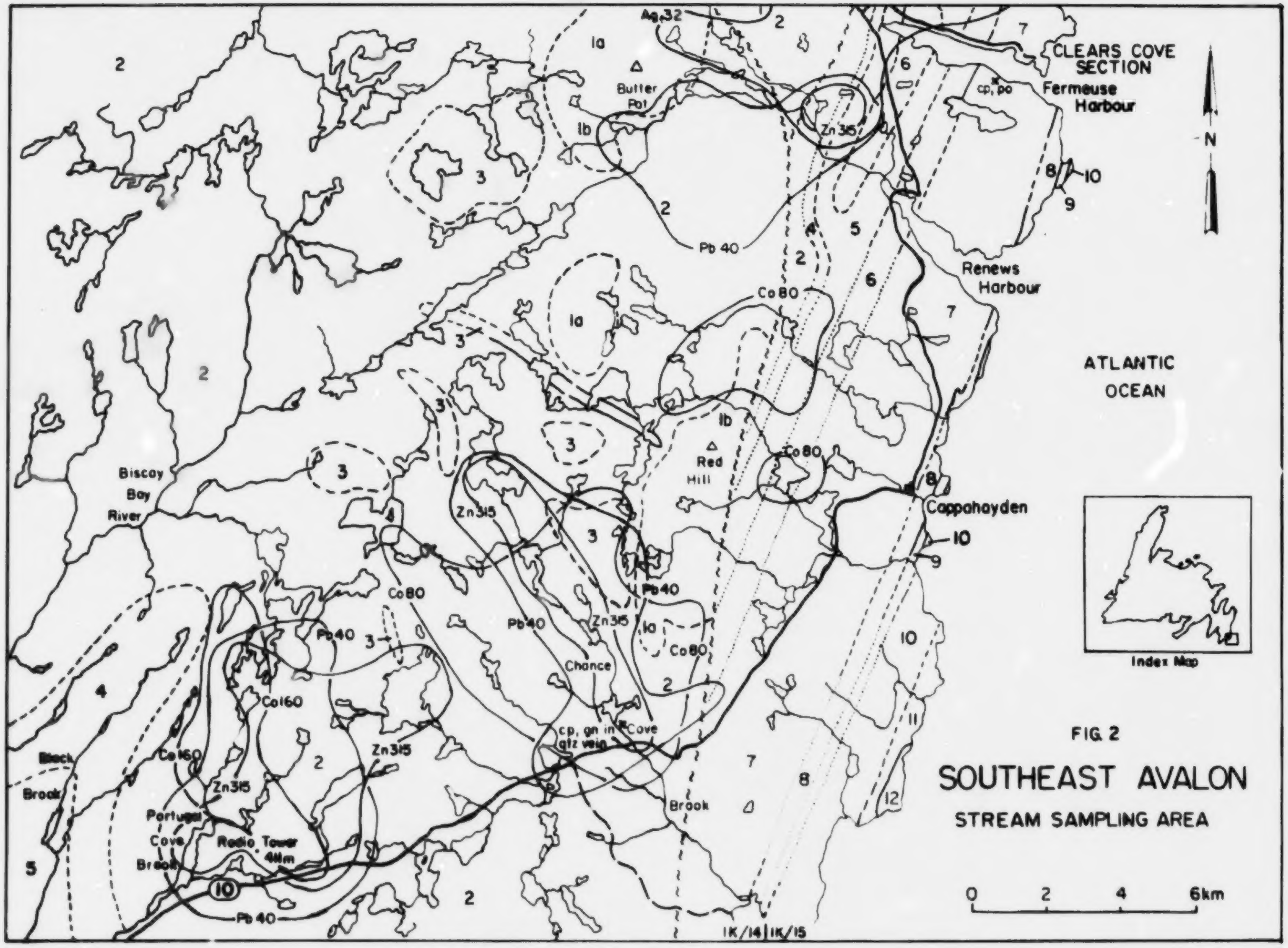


FIG. 2

SOUTHEAST AVALON

STREAM SAMPLING AREA

LEGEND FOR SOUTHEAST AVALON

HADRYNIAN

SIGNAL HILL GROUP

12 CAPE BALLARD FORMATION: gray shale and siltstone with minor purple shale, thick-bedded gray sandstone and quartz granule conglomerate.

11 FERRYLAND HEAD FORMATION: thick-bedded light gray sandstone with alternating units of thin-bedded dark gray sandstone and siltstone.

9 CAPAHAYDEN FORMATION: fissile parallel-laminated light gray siltstone.

ST. JOHN'S GROUP

8 RENEWS HEAD FORMATION: irregular thin-bedded dark gray sandstone with minor shale.

7 FERMEUSE FORMATION: gray to dark gray and black shale with thin lenses of buff-weathering sandstone and siltstone. Mainly light gray thin-bedded shale and sandstone toward base.

6 TREPASSEY FORMATION: medium- to thin-bedded gray sandstone and shale, graded sandstone beds with shale tops.

CONCEPTION GROUP

5 MISTAKEN POINT FORMATION: medium-bedded gray to pink sandstone and green to purple and red shale, minor thin tuff horizons.

4 BRISCAL FORMATION: thick-bedded coarse gray sandstone, thick-bedded olive to gray argillite, coarse pale red sandstone and arkose.

3 WHALESBACK GABBRO: fine- to medium- and coarse-grained massive gabbro.

2 DROOK FORMATION: parallel-bedded olive green to gray and buff argillaceous chert, siliceous siltstone and sandstone, silicified tuff, locally includes thick sandstone beds alternating with shale and siltstone, minor purple argillite.

1 HARBOUR MAIN GROUP: poorly bedded, bimodal volcanic rocks; la, pink to gray silicic tuff and agglomerate, pink to red rhyolite and welded tuff; lb, altered green to purplish massive basalt.

Geology from GSC Memoir 389 by Williams and King, 1979.

Lake Sediment Geochemistry from Mineral Development Division, Open File Releases: NFLD 879, by Davenport et al., and NFLD 1003, by Butler and Davenport.

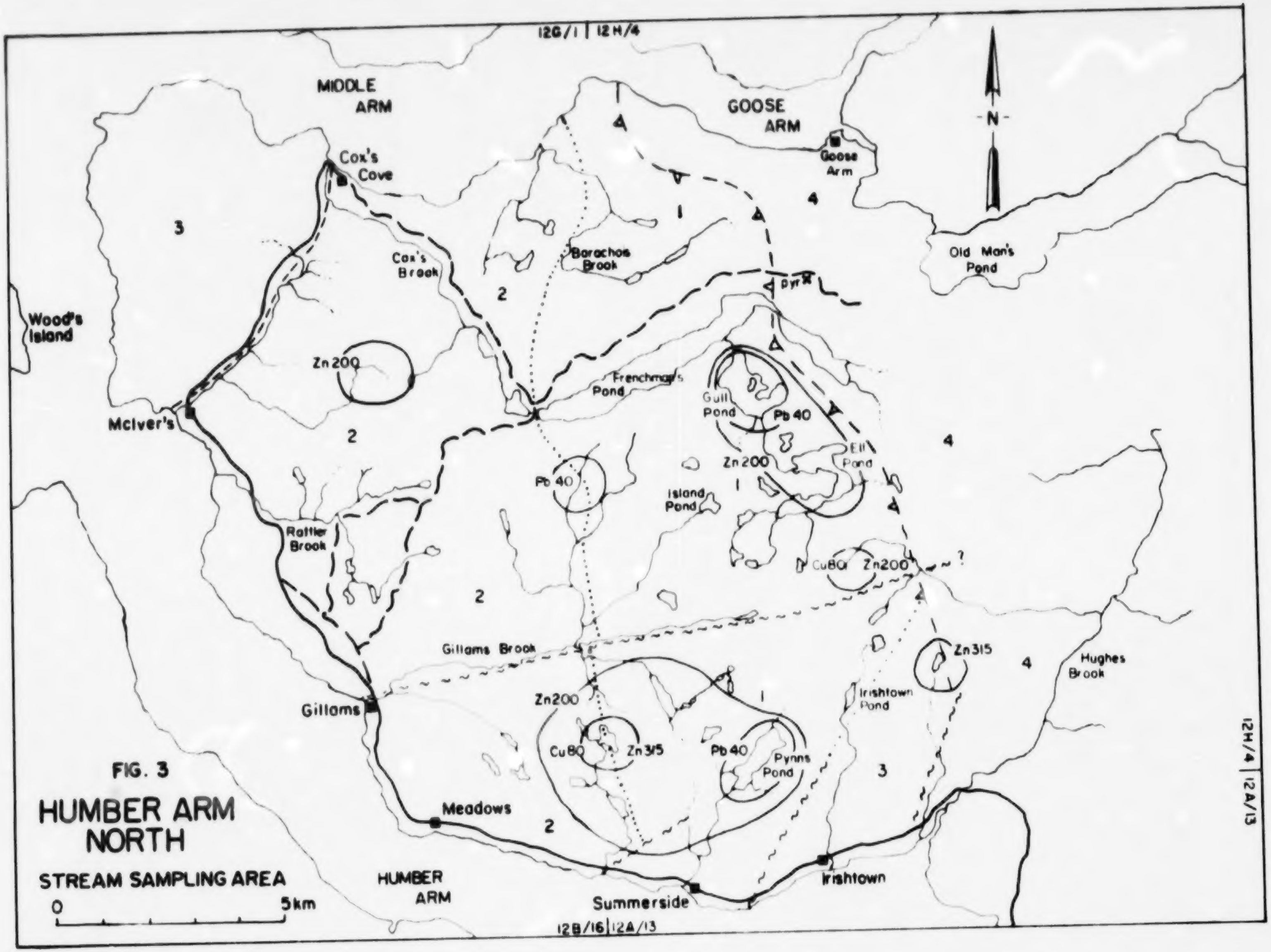


FIG. 3

HUMBER ARM NORTH

STREAM SAMPLING AREA

LEGEND FOR HUMBER ARM NORTH

AUTOCHTHONOUS CARBONATE TERRANE

UPPER CAMBRIAN TO MIDDLE ORDOVICIAN

4 ST. GEORGE AND TABLE HEAD GROUPS: medium- to thick-bedded limestone and dolomite with thin shale units.

HUMBER ARM ALLOCHTHON

MIDDLE CAMBRIAN TO LOWER ORDOVICIAN

3 COOKS BROOK FORMATION: thin platey limestone beds which alternate with black shales. The middle part of the formation contains limestone breccia.

LOWER TO MIDDLE CAMBRIAN

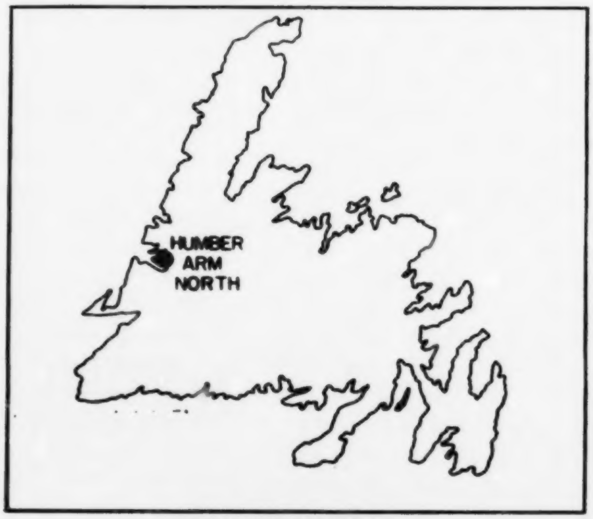
2 IRISHTOWN FORMATION: dark brown, gray, black, and locally voilet shales, with interbeds of siltstone, white and brown quartzite, graywacke, dolomite and conglomerate.

LOWER CAMBRIAN AND OLDER (?)

1 SUMMERSIDE FORMATION: the lowest beds are dark gray shales; these are overlain by brownish-green and reddish quartzites and siltstones; the upper part consists of distinctive red and green, shales and slates, overlain by silvery blue, black banded shales.

Geology from Stevens (1965), and Williams et al. (1981), GSC Paper 82-1A.

Lake Sediment Geochemistry from Mineral Development Division, Open File Releases: 12G/74 and 12H/570.



INDEX MAP FOR FIG.3

continuous to discontinuous and lensoid, wavy to contorted, and variable in thickness from 1 mm to 2 cm. The Carbonear Formation is finer grained in its eastern exposures along Conception Bay where it is referred to as soft gray to black slate by Hutchinson (1953) and McCartney (1967). In the west, the Carbonear Formation grades upward into the massive, light green quartzitic sandstone of the Halls Town Formation, the upper unit of the Hodgewater Group. The Hodgewater Group is the central Avalon Peninsula's equivalent of the St. John's and Signal Hill Groups to the east (King, 1980).

Mineralization is present throughout the upper Carbonear Formation, but to a lesser degree in its lower stratigraphic levels. The sulphides consist of 1-5% disseminated pyrrhotite + pyrite and preferentially occur in the coarser laminations and beds. Large rusty sulphide-bearing outcrops are present north of Gull Pond and immediately north and east of Hard Weather Pond. In the latter area chalcopyrite and galena occur locally with the pyrrhotite. A weakly mineralized 36 m coastal section of the upper Carbonear Formation, north of Perry's Cove, was mapped and sampled in detail. Quartz chip samples and whole rock samples were collected from across the area and are presently being analyzed along with the silts and section samples.

Humber Arm North

Localized Zn, Cu and Pb anomalies are present in lake sediments overlying Cambrian clastics of the Humber Arm Supergroup (Butler and Davenport, 1980). The Humber Arm area lies east of the Bay of Islands. It is bounded to the south by the Humber Arm, to the north by Middle Arm, to the west by the McIver's-Cox's Cove road and to the east by a line joining the town of Goose Arm in the north to the mouth of Hughes Brook in the south.

Topographically, the area resembles a large dissected plateau sharply rising 150-200 m above sea level and having several interior mountains reaching altitudes of 300-400 m. The southern half of the area is predominantly drained by the deeply incised, west flowing Gilliams and Rattler Brooks, their many tributaries, and by much smaller brooks which drain south into the Humber Arm. The northern half is drained by short brooks which empty into the northeast trending Frenchmans Pond Valley, which itself drains northwest into Cox's Cove Brook. A small area north of Frenchman's Pond is drained by Barachois Brook and the broad valley which parallels the McIver's-Cox's Cove road drains southwest via an unnamed brook. Silt development was good to excellent in the area due to the relief and vegetation in western Newfoundland.

The area is underlain by the highly deformed Summerside and Irishtown Formations of the Humber Arm Supergroup (Brückner, 1966). The older Summerside Formation is described by Stevens (1965) as consisting of a lower arenaceous unit and an upper argillaceous unit. The lower unit is composed of green and red argillaceous sandstones which are locally subarkosic or conglomeratic. The upper unit is characterized by a distinctive red and green slate sequence containing very thin beds (1-3 cm) of laminated siltstone which are internally contorted. The slates grade upward into silvery blue and gray, well cleaved shales having closely spaced black bands (2 to 5 cm apart) which average 1 cm thick. The Irishtown Formation (referred to as the Meadows Formation by Stevens, 1965) is composed of dark brown, gray, and black shales, with interbeds of siltstone, white and brown quartzite, graywacke, dolomite, and conglomerate (Brückner, 1966). In addition, thick units of dark brown to black shales were observed, typically isoclinally folded, and containing intercalations of thin white siltstone averaging 3 mm in thickness. Throughout the area, a north-northeast trending, vertically dipping foliation characterizes the regional structural fabric.

To the west of the Summerside and Irishtown Formations lies the Bay of Islands Igneous Complex. To the east lies an autochthonous carbonate (and clastic) sequence interpreted as representing an early Paleozoic continental shelf (Williams *et al.*, 1982). The Summerside and Irishtown Formations form part of the Humber Arm Allochthon, which is interpreted as a continental slope/rise sequence deposited to the east of the continental shelf, and later thrust westward across it (Williams *et al.*, 1982).

Mineralization in the area consists of rich concentrations of pyrite in quartz sandstone; nodules, lenses and veinlets of pyrite in carbonaceous shale; and minor disseminated sulphides scattered throughout the area. A 20 m section of well cleaved carbonaceous shales of the upper Table Head Formation is exposed in a roadcut north of Frenchman's Pond. Pyrite is present in amounts up to 5%, as small rounded nodules, disseminated crystals, sugary textured lenses (<1 cm thick), and veinlets parallel to the cleavage. The shales are similar in appearance to Caradocian shales seen in Central Newfoundland (Dean and Meyer, 1982) and were chip sampled in 3 m intervals. An additional 24 shale chip samples were collected from outcrops in brooks from across the area and are presently being analyzed.

Banded pyrite was observed in fine grained quartz sandstone float found in Barachois Brook. The mineralized float, which contains 30-40% pyrite, is possibly derived from the lower arenaceous unit of the Summerside Formation. There is a large roadcut of shale and interbedded sandstone of the Irishtown Formation on the north side of the arterial road in Corner Brook between the paper mill and the bus station. The 6-10 cm thick quartz sandstone interbeds contain up to 75% pyrite. Samples of this unit are currently being analyzed for the presence of additional metals.

Brooms Brook Section

A 22 m section of black, laminated mudstones and siltstones was mapped and sampled in detail on the northeast bank of a tributary of Brooms Brook in the southern Anguille Mountains of Western Newfoundland. Brooms Brook enters the Grand Codroy River from the north, halfway between the towns of Millville and O'Regans. A road, which deteriorates into a horse trail, leads 3.5 km along the northwest side of Brooms Brook to where the tributary flows in from the northwest. The section is 2.5 km upstream, within the Friars Cove Formation of the Mississippian Anguille Group (Knight, 1982).

The southeast facing section is bounded to the northwest by a zone of fault breccia (less than 15 cm thick) with calcite infilling and coarse crystalline masses of pyrite. The top of the section, and part of the middle, are covered in slumped riverbank deposits. Evidence of large scale folding and faulting of this formation is present downstream.

The section is composed of mudstones and siltstones which are black and very finely laminated. Beds range in thickness from 2 to 30 cm, and are moderately fractured and veined with calcite. The top half of the section is more carbonaceous and sulphur-rich. Traces of chalcopyrite are present in a third of the intervals, as thin veinlets as well as disseminations on fracture planes. Small euhedral crystals of galena were observed on similar fracture planes, but are less abundant. Bands and lenses of pyrite 2 to 4 mm thick are present near the top of the section. All chip samples are undergoing complete analysis for Cu, Pb, Zn, Ag, Ba, Fe, Mn, C, Ni, Co, As, U, and F, as well as major elements. Comparisons will be made with sections from across the province in a further in depth study.

CONCLUSIONS

A total of 438 silt samples were collected from the three delineated work areas. In addition, 48 whole rock and 30 quartz chip samples were taken and three sections were mapped and sampled in detail. The most significant mineralization occurs within the Northwest Avalon where the upper Carbonear Formation hosts 2-5% sulphides (dominantly pyrrhotite) in most exposures. The silt and rock samples are presently being analyzed and results will be released on open file when available.

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BARITE EVALUATION - EASTERN AND WESTERN NEWFOUNDLAND

by

A.F. Howse and V.A. French

SUMMARY

A survey of barite occurrences in eastern and western Newfoundland was carried out during the 1982 field season. Work on the east coast consisted primarily of a coastline survey along the shores of Trinity Bay (Colliers Point to Sunnyside) and Placentia Bay (Trinny Cove to Arnold's Cove). Bedrock exposure along the coast is excellent and consists mainly of late Precambrian volcanic and sedimentary rocks. Numerous, narrow (<20 cm) barite veins were identified on the Trinity Bay section of coastline. They appear to occupy small fissures and are commonly associated with quartz and (or) calcite. The most promising area, the Bellevue Peninsula, has at least six barite zones or vein systems which cut arkosic sandstone of the Snows Pond Formation. The widest veins are located in the Tickle Point - Tickle Cove area of the Bellevue Peninsula. Some of these coincide with air photographic lineaments interpreted to be faults.

Work on the west coast was carried out in selected areas in the Codroy - St. George's Carboniferous basin and on the Port au Port Peninsula. It consisted mainly of detailed prospecting and mapping along streams. Stream sediment geochemical surveys conducted in 1973 and 1974 (Davenport *et al.*, 1975; McArthur *et al.*, 1975) indicated that the silts in parts of these streams contained anomalous amounts of barium, copper, zinc, and lead. As a result of the follow-up program, several new mineral showings were identified. Most are located in areas underlain by shales and sandstones of the Lower Mississippian Anguille Group, while others are hosted by the basal limestones of the overlying Mississippian Codroy Group.

AVALON PENINSULA - Results

Barite is widely distributed throughout the Isthmus of Avalon and along the east coast of Placentia Bay (Figure 1). It occurs in veins with or without quartz and calcite. It also occurs as a late mineral in the La Manche galena-calcite vein, and as a very minor gangue mineral at the Silver Cliff lead-zinc-silver deposit near Argentia (Chute, 1939). The veins cut strata of every age in the area, from the oldest Connecting Point Group of late Precambrian age to the various lower Cambrian formations. The veins are remarkably similar in appearance. Most are salmon pink and consist of bladed or tabular crystal aggregates. Contacts with their host rocks are usually sharp with little or no wall rock alteration. The veins range in thickness from a few centimetres to one metre. Joints near the veins are commonly filled with barite.

One notable exception is the Collier Point vein where the width, as measured by McArthur (1973), showed a maximum thickness of 3.6 m. About 5000 t of barite was produced from this deposit between 1902-04 and in 1980 J. Tyler Mining Ltd. produced about 9000 t from a surface open cut before operations ceased. The vein dips approximately vertically and is in sharp contact with the wall rock, which consists of gray-green arkose of the Hodgewater Group. Recent attempts to exploit the deposit have exposed the vein for about 600 m along its 160° strike. The thickness of this newly exposed section ranges up to 1 m.

Road construction to the prospect uncovered a new vein within 150 m of the old vein and parallel with it. It has

Contribution to Canada-Newfoundland co-operative mineral program 1982-84. Project carried out by Newfoundland Department of Mines and Energy.

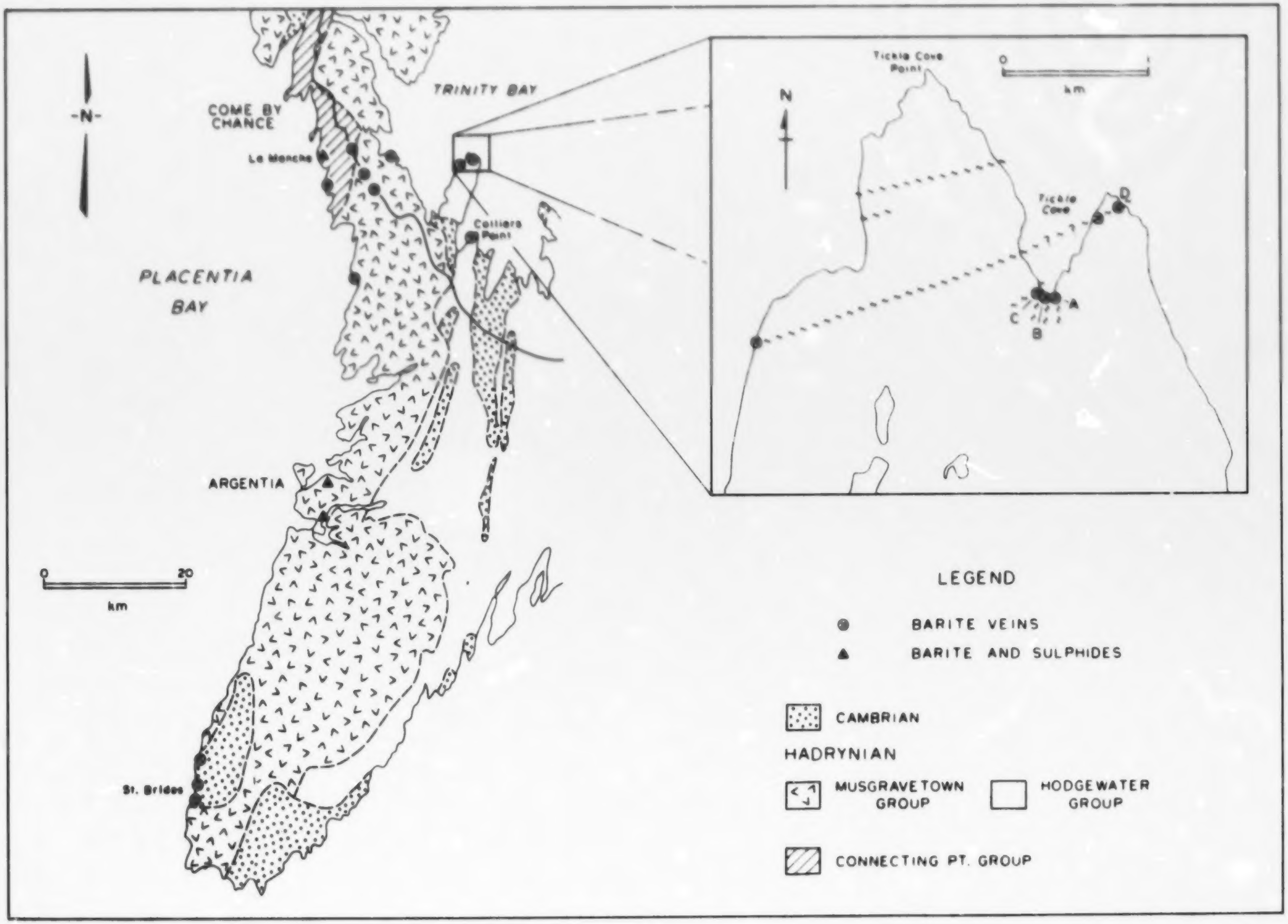

Figure 1: Barite occurrences on the western Avalon (modified after McArthur, 1973) - insert shows occurrences in the Tickle Cove area of the Bellevue Peninsula.

been traced along strike for 100 m and has a maximum thickness of about 35 cm.

The Bellevue Peninsula constitutes a promising yet relatively unexplored area for barite. The coastal survey identified several veins containing barite, calcite and quartz. The proportion of barite ranges from 30% to 100%.

The widest veins are located in the Tickle Point - Tickle Cove area of the Bellevue Peninsula (Figure 2). In Tickle Cove, a small indentation near the northern tip of the peninsula, three narrow subparallel barite veins occur in close proximity. The following is a description of these veins going from west to east:

VEIN A - A pink and white barite vein exposed in a 4.5 m cliff. The vein has a maximum width of 30 cm at the top pinching to 3 cm at the base of the cliff. The host rock is a highly fractured, green, crossbedded arkose with gray silty lenses. The vein strikes 180° and dips W at 75°. On the vein's hanging wall side, narrow veinlets of barite intersect the main vein at acute angles.

The vein appears to be localized along a steeply dipping fault structure which cuts across the gently (southward) dipping bedrock.

VEIN B - The vein consists of pink and white bladed crystals of barite exposed in a 4 m cliff. The vein dips vertically, and can be traced inland (190°) for about 8 m before it is obscured by cobbles and boulders. It maintains a consistent 15 cm thickness and contacts with its arkosic host are very sharp.

VEIN C - This vein is 70 cm wide at beach level, strikes 020°, and dips 80°W. It consists of pink and white barite, some in bladed crystal form, and quartz. The vein narrows to about 10 cm at the top of a 9 m cliff. The vein occurs in flat-lying green arkose which is highly fractured at the footwall contact. The hanging wall is much less disturbed and contains narrow stringers of barite which parallel the main vein. What appears to be an extension of the barite-quartz vein structure was traced northward beneath the waters of the cove for several metres. A sample of this submarine zone shows a dendritic pattern of narrow barite and quartz veinlets (average <1 cm wide), giving the host arkosic sandstone a brecciated appearance.

A zone of 8 narrow barite veins occurs on the extreme western side of Tickle Cove. They vary in width from 1 to 6 cm, with an average width of 2.5 cm. The veins strike about 240° and dip vertically. A northeast striking fault marks the northwest limit of barite mineralization in this area.

VEIN D - This vein appeared on a 1:253,440 scale geological map by McCartney (1967) and was described by McArthur (1972). The vein consists of barite, quartz, and chlorite. It occurs at the eastern extremity of a fault zone which forms a prominent lineament across the tip of the Bellevue Peninsula trending 070°. The vein varies in width from 2.1 m at the base of a 15 m cliff to 1 m near the

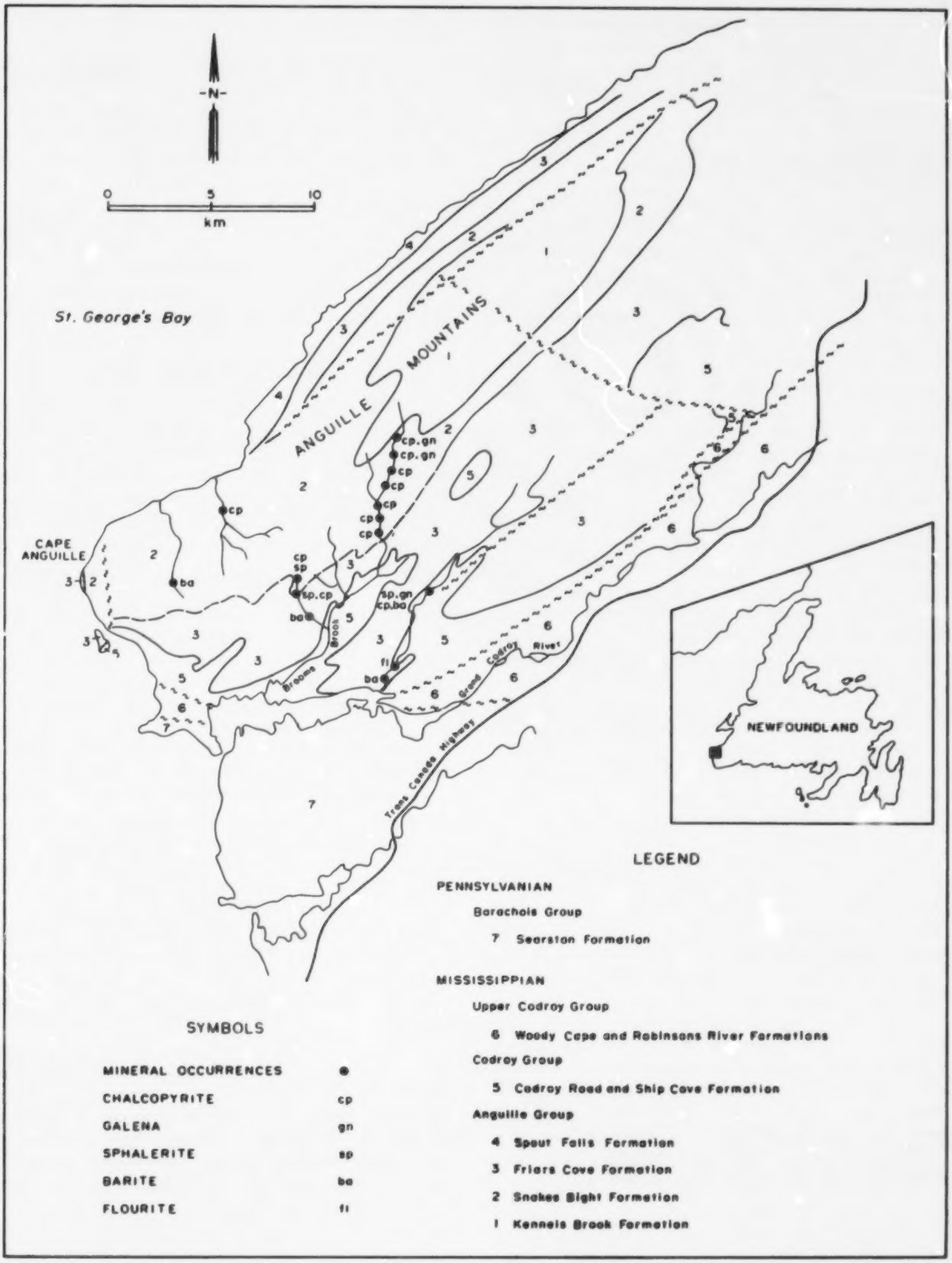

Figure 2: Sketch map showing location of mineral showings in the Codroy - Anguille Mountains area (geology after Knight, 1974).

top. The barite tends to be concentrated on both sides of the vein, and makes up approximately 33% of vein constituents.

ST. BRIDES AREA - Barite

Two barite veins were examined in the St. Brides area on the eastern side of Placentia Bay. The widest is exposed in a small cove about 0.7 km southeast of Cross Point. The vein consists of white to salmon-pink barite occurring as bladed crystal aggregates. Approximately halfway up a 25 m cliff, it has its maximum width of 1.5 m. At beach level, the vein is split into two sections, 0.4 m and 1.0 m wide, respectively. The two limbs are separated by a 0.7 m section of red shale. At the top of the cliff the vein narrows to 0.3 m and cannot be traced inland. The vein strikes 020° and dips 80° to the southeast. The host rocks are Eocambrian red shales and siltstones. In a 15 m wide zone immediately west of the vein, these rocks are tightly folded into isoclinal and recumbent folds. To the east of the vein, there is no evidence of folding. A distinct 30 cm wide quartzite bed was traced on both sides of the vein. It shows little of the axial planar cleavage seen in the less competent, folded shales and siltstones.

The Cuslett barite vein is located about 0.5 km north of the community of Cuslett on the east shore of Placentia Bay. The vein consists of well developed bladed crystals exposed along a 30 m high cliff. The vein's maximum width (1 m) is 4 m above low water mark, with a minimum width (6-7 cm) halfway up the cliff, widening to 0.5 m at the top. The vein is traceable for 8 m from low water mark to the base of the cliff. It is not traceable inland. The vein strikes 052° and dips vertically. The host rock is pebble conglomerate consisting of subrounded to rounded feldspar, quartz, sedimentary and volcanic pebbles.

Other Results

A zone of lead mineralization was discovered on the north tip of Loon Point about 1 km west of the community of Bellevue. Galena and pyrite occur as blebs and disseminations in quartz and calcite fracture fillings in a zone of brecciated siltstone that is oriented at 080°/85°N. The attitude of the bedding in the area of the showing is 140°/18°SW. The mineralization is sporadic and can be traced for about 8 m along the strike of the zone.

WEST COAST - Results (Barite)

The results of follow-up work on geochemical stream sediment anomalies for barite (and base metals) in the Codroy - St. George's Carboniferous basin are summarized in Table 1, which includes the NTS sheet reference and UTM coordinates for all new mineral showings.

Nearly all of the barite that was identified in Carboniferous strata occurs as narrow veins ranging in thickness up to 20 cm. Barite with quartz and calcite were observed in brecciated zones in Anguille Group sandstones. Narrow veins of mixed barite and calcite were also noted in Ship Cove limestone of the Codroy Group. In one showing, on Brooms Brook, barite mixed with calcite occurs as gangue in narrow mineralized fractures containing sphalerite, chalcopyrite, and galena in Ship Cove limestone. On Table Mountain, an area which showed anomalous amounts of barium in both stream and lake sediments, narrow veinlets of barite cut red and gray sandstones of the Anguille Group.

Approximately 1.5 km inland from the south shore of Picadilly Bay on the Port au Port Peninsula, pink and white bladed crystals of barite occur with celestite in vuggy Codroy Group limestone along a 15 m section of a stream bed. The

TABLE I LOCATION AND DESCRIPTION OF NEW MINERAL SHOWINGS

UTM GRID REFERENCE	HOST ROCK	MINERALS	REMARKS
330250E 5305500N NTS 110/14	sandstone, Anguille Group	barite	Pink and white barite and calcite veins in a zone of brecciated sandstone. Zone trends 040°/75°NW. Vein is 20 cm wide at the top of a 5 m cliff and is reduced to stringers at the base. Estimated 50% barite, 50% calcite.
329750E 5305800N NTS 110/14	sandstone, Anguille Group	chalcopyrite	Finely disseminated chalcopyrite in thin films of calcite on fracture planes in folded and highly fractured sandstone. Mineralized zone trends 035°/vertical.
329450E 5306600N NTS 110/14	black shales, Anguille Group	chalcopyrite, sphalerite	Lenses of sulfides (<1 cm) occur in laminated mudstones in several zones along a 400 m section of a stream. Chalcopyrite also occurs as blebs and disseminations associated with calcite veins.
334350E 5312900N NTS 110/14	black shales, Anguille Group	galena, chalcopyrite	Disseminated galena and chalcopyrite in narrow veins of calcite in fractured shales.
334100E 5312500N NTS 110/14	black shales, Anguille Group	galena, sphalerite, chalcopyrite, pyrite	Banded (pyrite-rich) sulfides in shales; also minute blebs of galena and pyrite in fault breccia trending 120°/75°E. Sulfides also associated with thin limy bands (5-8 cm) in shales.
334000E 5312450N NTS 110/14	limestone - shale, Anguille Group	barite	Thin barite veins (max. 6 cm) with calcite. The veins are associated with thin (max. 8 cm) shale bands in an interbedded shale and limestone zone which strikes 038°/55°SE.
334050E 5311950N NTS 110/14	sandstone, Anguille Group	chalcopyrite	Clots of chalcopyrite up to 1 cm in diameter associated with quartz and minor calcite in a brecciated zone in tightly folded sandstone. Zone is 1 m wide, not traceable along 020° strike.
333900E 5311350N NTS 110/14	black shales, Anguille Group	galena, chalcopyrite	Blebs and dissemination in black shales; also nodules of massive sulfide (mainly pyrite). 15 m section of shales exposed on east bank of stream. Attitude of bedding 065°/65°S.
333300E 5310650N NTS 110/14	black shales, Anguille Group	chalcopyrite, pyrite	Banded sulfide in a zone of rusty (weathered) shales. Pyrite crystal aggregates 2 cm in diameter; calcite veins normal to bedding.
333300E 5310350N NTS 110/14	black shales, Anguille Group	chalcopyrite, pyrite	Banded sulfides (pyrite-rich) in tightly folded black shales -- 020°/80°SE.
333500E 5310200N NTS 110/14	mudstone, Anguille Group	galena	Calcite vein with galena. Average width 3 cm, traceable for 5 m.
334950E 5306150N NTS 110/14	Ship Cove limestone, Codroy Group	sphalerite, galena, barite, pyrite	Fractures contain sphalerite, galena and chalcopyrite, with calcite and barite. Zone trends 160°/65°NE and can be traced 8 m along strike.
334150E 5306025N NTS 110/14	Ship Cove limestone, Codroy Group	fluorite	Small crystals of fluorite associated with calcite veins in limestone. Fluorite was observed in several localities along strike of the limestone for about 100 m. Fluorite also found in irregularly shaped vuggy blebs of calcite.
326150E 5310700N NTS 110/14	black shales, Anguille Group	chalcopyrite, pyrite	Thin bands of pyrite (<0.25 cm) and disseminated chalcopyrite occur in a zone of mudstone and siltstone along a 75 m section of Low Brook. Chalcopyrite is mainly associated with calcite- and quartz-filled fractures normal to the bedding.
358950E 5378700N NTS 12B/10	limestone, Table Head	galena	Galena occurs as minute crystals that protrude on the weathered surface of fracture planes in limestone.
359000E 5378750N NTS 12B/10	limestone, Codroy Group	barite, celestite	Mineralized float consisting of vuggy limestone with white and pink barite and blue celestite occur for 15 m along stream bed.
368250E 5378900N NTS 12B/10	conglomerate	galena, marcasite, pyrite	Blebs and disseminations in matrix of conglomerate. Subangular to rounded clasts of limestone, dolomite, and minor chert range from pebble to boulder size. Framework: clasts 90%, matrix (sandy) 10%. Poorly sorted. Galena associated with finer phase.

mineralized float resembles that seen near other localities on the Port au Port Peninsula where small deposits of mixed barite and celestite are known to occur. Most notable of these is the Ronan deposit on Hooper's Brook near the community of Boswarlos. This deposit has been well delineated by diamond drilling (Johnson, 1954; McArthur, 1973). It is wedge-shaped longitudinally, lens shaped in cross-section, and contains about 135,000 t grading 35% $BaSo_4$ and 25% $SrSo_4$. McArthur (1973) reported that metallurgical testing of representative bulk samples indicated solid solutions of barite in celestite and vice versa. The difficulty in separating the celestite from the barite was probably a factor in preventing the wartime development of the deposit as a source of strontium for pyrotechnics. The barite and celestite occur as partial or total replacements of the host Carboniferous Codroy Group strata.

Other Results

Although the emphasis was on searching for barite, a number of base metal showings were also identified. Some of these were on streams that gave coincidental anomalies for copper, lead, zinc and barite in the 1973-74 geochemical surveys.

Chalcopyrite, sphalerite, and galena were observed in black shales and sandstones of the Anguille Group, in a number of localities along tributaries which flow off the Anguille Mountains into Brooms Brook. The shales host thin concordant bands of sulfide in addition to clots and disseminations of chalcopyrite, galena and rare sphalerite in calcite-filled discordant fractures. The host rocks are characteristically tightly folded and, since the streams usually crosscut the formations, it is likely that some of the mineralized black shales seen along the brook are repeated zones.

Sphalerite, galena, and chalcopyrite were observed in a zone of fractured limestone (Ship Cove) on Ryans Brook. The zone has the attitude $160^{\circ}/65^{\circ}$NE and can be traced for about 8 m along strike. The mineralization, along with barite and calcite, fills tension fractures along the axial plane of a tight fold.

A zone of fluorite mineralization was traced for about 100 m along the northwest bank of Ryans Brook. The zone follows the attitude ($038^{\circ}/30^{\circ}$SE) of the host Ship Cove limestone formation and consists of minute cubes of fluorite associated with irregularly shaped blebs and veinlets of calcite in the limestone. The calcite veins trend E - W and dip vertically. They range in thickness from <1 cm to 15 cm but the fluorite is restricted primarily to the larger veins and blebs of calcite.

Minor galena was observed with marcasite and pyrite about 1 km up Gilliam's Brook on the north shore of the Port au Port Peninsula. The mineralization occurs as blebs and disseminations in the sandy matrix of Carboniferous conglomerate-breccia. Subangular to rounded clasts of limestone and dolomite ranging from pebble to boulder size comprise 90% of the rock. The mineralization occurs in an area where Carboniferous Codroy Group rocks have been deposited in small grabens of the Ordovician Table Head limestone.

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GEOLOGY AND MINERAL DEPOSITS OF THE LUSH'S BIGHT GROUP IN THE LITTLE BAY HEAD - HALLS BAY HEAD AREA

by

B.F. Kean

INTRODUCTION

This report summarizes the initial results of a project designed to investigate the regional geology and mineral deposits of the Springdale Peninsula. The objectives of this project are to establish a stratigraphic and structural framework for the Lush's Bight Group, to study the deposits in the area, to evaluate their economic significance in terms of the regional geology and to provide a model for the area that will prove useful in the search for economic mineral deposits.

Access to the area is via the Springdale and Little Bay Roads and via boat from Springdale and St. Patricks. Bedrock exposure along the coast is excellent and nearly continuous; elsewhere it is poor.

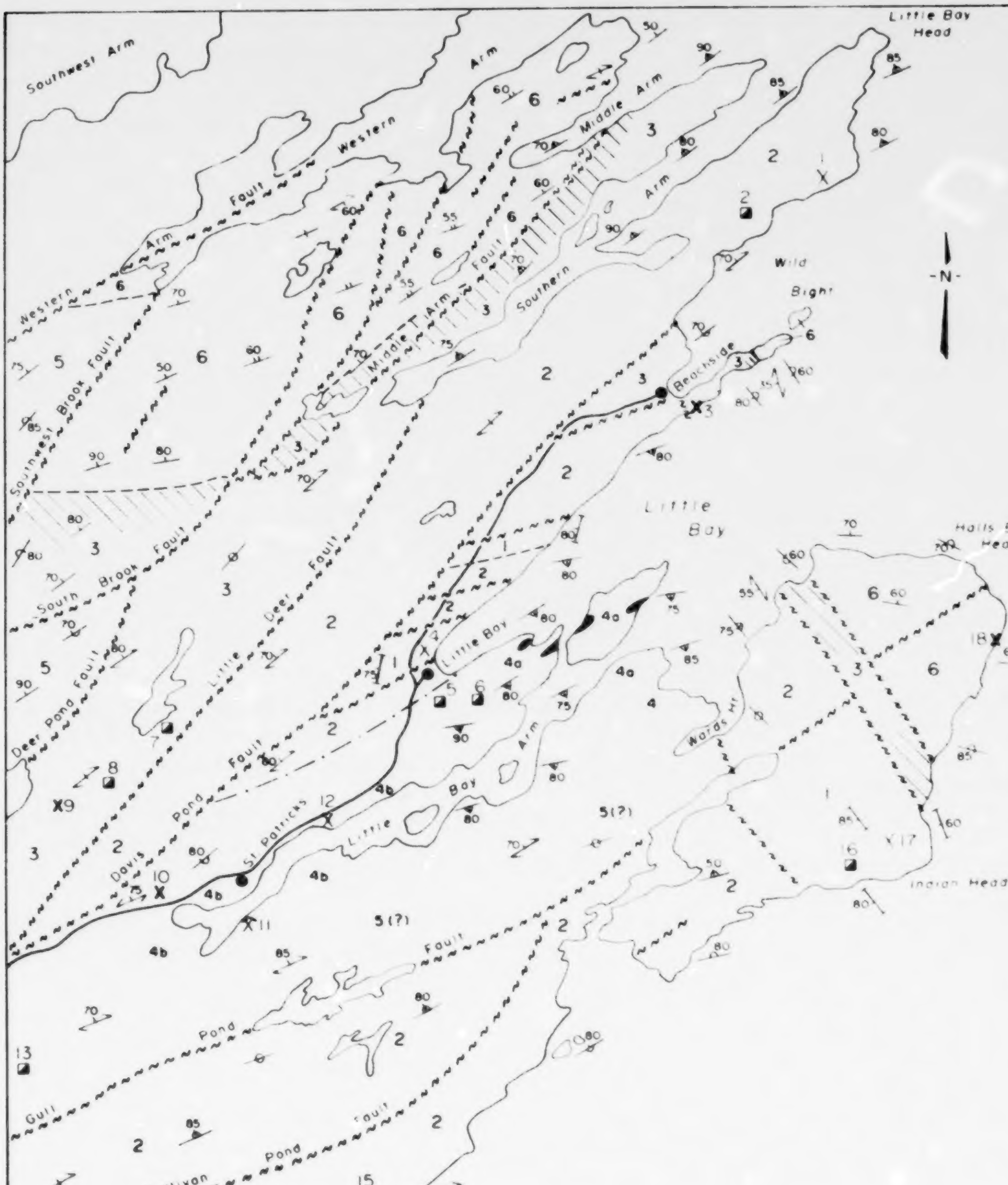
Approximately six weeks of field studies were carried out in the Little Bay Head - Halls Bay Head area during the 1982 field season. This area provides the best sections through the Lush's Bight Group and contains a large number of mineral occurrences as well as past-producing mines at Little Bay and Whalesback (Andrews, 1980). Much of the area has been extensively mapped and explored by Brinex during the 1960's and early 1970's. A number of theses (*e.g.* Donohoe, 1968; Fleming, 1970; Marten, 1971a; DeGrace, 1971; West, 1972; Kean, 1973; O'Brien, 1975) supported by Brinex have been done on the area and these add to a voluminous data base. MacLean (1947) and Williams (1962) have produced regional maps of the area, and Dean and Strong (1975) compiled the area on a scale of one inch to one mile.

However, despite this great volume of geological data, the Lush's Bight Group has generally been shown (and mapped) as an undivided sequence of pillow lava, chlorite schist and basic intrusive rocks. Consequently, the main objective of the field season was to elucidate the stratigraphy and structure of the Lush's Bight Group in the Little Bay Head - Halls Bay Head areas and to establish whether the stratigraphy and/or structure had any control on the mineralization in the group.

The main results of the 1982 field season are:

1. The Lush's Bight Group does contain an identifiable and mappable ophiolite stratigraphy;
2. The stratigraphy is discontinuous and is mappable within fault boundary blocks;
3. Structural repetition by folding and faulting accounts for the present large exposure area of the Lush's Bight Group and its thickness is probably 3-4 km although the base is not exposed;
4. The mineralization occurs in chlorite schist zones at different stratigraphic levels within the pillow lava sequence at various distances from the sheeted dike-pillow lava contact;
5. The chlorite schist zones are early structures that are not lithologically controlled, are not primary controls for mineralization, and are both barren and mineralized.

Contribution to Canada-Newfoundland co-operative mineral program 1982-84. Project carried out by Newfoundland Department of Mines and Energy.


Southwest Arm
Western Arm
Western Arm Fault
Middle Arm
Middle T. Arm Fault
Southern Arm
Little Bay Head
Wild Bight
-N-
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Little Bay
Halls Bay Head
Southwest Brook Fault
South Brook Fault
Deer Pond Fault
Little Deer Fault
Davis Pond Fault
St. Patricks
Little Bay
Little Bay Arm
Wards Hr
Indian Head
Gull Pond Fault
Sullivan Pond Fault
HALLS BAY
0
1
2
km

LEGEND

SILURIAN OR DEVONIAN

8 **SPRINGDALE GROUP:** red and brown conglomerate, sandstone and siltstone.

ORDOVICIAN

7 **BOB HEAD PLUTON:** medium to coarse grained hornblende diorite and gabbro; pink to red quartz monzonite and granite.

6 **CUTWELL-WESTERN ARM GROUPS:** calc-alkaline mafic to felsic volcanic, epiclastic and sedimentary rocks.

CAMBRO-ORDOVICIAN

LUSH'S BIGHT GROUP

5 Undivided mafic pillow lava and pyroclastics, and diabase and gabbro dikes, sills and plugs.

4 **4a,** fine grained to aphanitic, green, commonly variolitic, altered pillow lava, minor breccia, agglomerate and tuff; quartz amygdules common; diabase dikes. **4b,** fine to medium grained, green pillow lava, massive flows and poorly pillowed flows; common gabbro dikes and sills.

3 Fine grained to aphanitic, gray to gray-green, epidotized pillow lava, minor breccia, agglomerate and tuff; black pillow lava with interpillow red chert common in upper parts of the unit; contains less diabase and gabbro than Unit 2. Feldspar, amphibole, feldspar-amphibole and pyroxene porphyry dikes are locally common.

2 Fine grained to aphanitic, gray-green to green, epidotized pillow lava with extensive diabase and gabbro dikes. Local sheeted dike zone. Minor agglomerate and breccia.

1 Sheeted diabase dikes; locally with gabbro and pillow lava screens.

6. The primary control is interpreted to be stratigraphic with 'shear zones' as a secondary structural control;

7. Zones of leaching and silicification occur at the same stratigraphic level, but laterally along strike, as the Little Bay and Sleepy Hollow Mines.

REGIONAL GEOLOGY

The regional geology of the Springdale Peninsula has previously been described by a number of workers including MacLean (1947), Williams (1962) and Peters (1967). Dean (1978) summarized the regional geology of Notre Dame Bay and the map area is included in a 1:250,000 scale geological compilation of the Newfoundland Central Volcanic Belt (Kean, 1977). The following regional discussion is in part adapted from Dean (1977).

The Lush's Bight Group occurs in western Notre Dame Bay, north of the Lobster Cove Fault. It outcrops between Southwest Arm in the west and Badger Bay in the east. The group is faulted against the Silurian-Devonian Springdale Group and the Ordovician - (?) Silurian Roberts Arm Group along the Lobster Cove Fault to the south. There are local outliers of the Springdale Group within the Lush's Bight Group north of the Lobster Cove Fault. These rocks are generally fault bound; however, an unconformity on the Lush's Bight Group possibly exists in the Davis Pond area (McGonigal, 1970). It is conformably overlain by the Lower Ordovician Western Arm Group and presumably by the Lower Ordovician Catchers Pond Group to the north and west. The Lush's Bight Group is faulted against the upper part of the Cutwell Group on the northeast coast of Sunday Cove Island. This fault is presumed to continue underwater between Long Island and Pilley's Island and juxtapose these groups in that area.

The Lush's Bight Group is considered to be of ophiolite affinity. However, the Lush's Bight Group as defined by Espenshade (1937) and used by MacLean (1947) also included sedimentary and volcanic rocks now considered to be of island arc affinity. These rocks have subsequently been assigned to the Western Arm Group (Marten, 1971a) and the Cutwell Group (Kean, 1973; this report). Thus the group now includes only mafic pillow lava, breccia and agglomerate, sheeted diabase dikes, gabbro dikes and sills and small bodies of ultramafic rock of ophiolite type. These rocks are low potash tholeiites with strong chemical similarities to modern oceanic crust (Papezik and Fleming, 1967; Smitheringale, 1972; Strong, 1973).

The Lush's Bight Group is folded into a major northeast trending anticlinorium and synclinorium with the limbs displaced or cut off by northeast trending wrench faults.

The Lush's Bight Group is intruded by various intrusives of probable Ordovician age including the Colchester Pluton, the Burlington Granodiorite and many small stocks and plugs interpreted to be contemporaneous with volcanism. It is also intruded by the Brighton Gabbro Complex, which gives an $^{40}Ar/^{39}Ar$ radiometric age of 495 ± 5 Ma (Stukas and Reynolds, 1974). An Upper Cambrian age is thus suggested for most of the group.

MacLean (1947) reported a single Lower Ordovician brachiopod, *Discotreta* sp., from the lowermost part of the conformably-overlying Western Arm Group.

The Lush's Bight Group and overlying calc-alkaline sequences are correlative on the basis of age and stratigraphy with the Snooks Arm Group, which includes the Betts Cove ophiolite. The two groups are interpreted to lie on opposing limbs of a major syncline.

THE LUSH'S BIGHT GROUP

General Statement

The Lush's Bight Group in the study area is an ophiolitic sequence consisting predominantly of a monotonous succession of altered mafic lava with minor intercalated pillow breccia, agglomerate and tuff. Locally, excellent examples of sheeted diabase dikes are preserved.

The contact with the overlying island arc assemblages of the Western Arm - Cutwell Groups (Unit 6) is generally faulted, but locally has been interpreted as conformable (Marten, 1971a, b). A conformable relationship between the two sequences is exposed in the Fox Neck area on the southeast side of Wild Bight and was mapped during this study. In the Fox Neck area altered black basalt, with epidotization occurring in veins and irregular patches, and with interpillow red chert and local hematization, is overlain by bedded sedimentary rocks. The base of the sedimentary section consists of interbedded red chert and chocolate brown argillite. Fine grained green tuff and chert, yellow-green tuff, gray and black argillite, and siliceous argillite first appear as thin interbeds in the red and brown sediments but are the main lithology within 100 m. Coarse pyroclastic breccia and pyroxene-plagioclase crystal vitric tuffs constitute the top of the succession in this area. Minor intercalated pillow lava occurs in the lower parts of the sequence.

The above described sequence is characteristic of the Lush's Bight/Western Arm - Cutwell Groups contact in this area, even where the contacts are faulted. Similar relationships and rocks have been described for the ophiolite/island arc contact in the Betts Cove area (Upadhyay *et al.*, 1971, page 31).

Fluviatile sedimentary rocks and terrestrial volcanic rocks of the Silurian-Devonian Springdale Group (Unit 8) generally have fault contacts with the Lush's Bight Group; however, an unconformity on the Lush's Bight Group possibly exists in the Davis Pond area (McGonigal, 1970).

The strong epidote alteration which is so characteristic of the Lush's Bight Group accompanied or predated the early stages of the regional deformation. This alteration and the L-S fabric accompanying the regional deformation decrease upwards in the sequence and are only very weakly developed in the overlying Western Arm - Cutwell Groups. Marten (1971a, b) referred to the resultant two types of lava found within the Lush's Bight Group as the "main facies" and the "black facies." The "main facies" is composed of green and gray-green, epidotized mafic lavas and is characteristic of the lower parts of the Lush's Bight Group. The "black facies" is composed of black, fresh to chloritic lava with epidote as veins and irregular patches. It is concentrated in the upper parts of the Lush's Bight Group but has no formational status. Marten (1971b) suggested a correlation with the "Whalesback type" and "St. Patricks type" lava divisions, respectively, proposed by Papezik and Fleming (1967) for the volcanic rocks in the Whalesback mine area.

Studies of metamorphism in ophiolites (*e.g.* Spooner and Fyfe, 1973) indicate that intense alteration and metamorphism of lower pillow lava units prior to deposition of upper pillow lava units is a common phenomenon. This is postulated to result from sub-seafloor hydrothermal metamorphism at active spreading ridges. The alteration facies developed in the Lush's Bight Group is thus interpreted to be a 'primary' alteration feature developed during the formation of the ophiolite.

Folds are mappable only on a large scale and the Lush's Bight Group is inferred to lie on the south limb of a major northeast plunging synclinorium, north of the Davis Pond Fault and on the north limb of a southeast facing synclinorium south of the fault. The anticlinal crest has been partially removed along the Davis Pond Fault. This fault is one of many postfoiding wrench faults that cut the Lush's Bight Group. The present large area of exposure is a result of structural repetitions and the true thickness is probably between 3 and 4 km.

Lithologies of the Lush's Bight Group

Generally, there is no recognizable stratigraphy in the Lush's Bight Group. However, sheeted dikes are locally recognizable. The group can be divided into a number of fault-bound blocks. The geology within each block is fairly homogeneous and regionally the blocks represent a rough stratigraphy; however, there is a repetition of lithologies or stratigraphy within and between blocks. The geology is discussed in terms of each block and the numbers on units do not reflect a strict chronological sequence.

Unit 1 - Sheeted Dikes

There are three main areas of 100% sheeted dikes in the map area, namely the Indian Head area of Halls Bay and two areas along the west side of Little Bay. The dikes trend slightly east of north with slight variation to the east and west and dip steeply to the west. In the Indian Head area the sheeted dikes are in fault contact with the pillow lavas, although pillow screens are common near the southwest contact. Facing directions are not known for this sequence. At the two localities on Little Bay, the dikes feed overlying pillow lavas to the southeast.

The sheeted dikes average about 0.5 m thick and vary from less than 0.25 m to 2 m thick. There are rare dikelets of aphanitic diabase less than 2 cm in width. The dikes are fine to medium grained, green, equigranular diabase with associated gabbro dikes and aphanitic black basalt dikes. The dikes generally display the classic chilling on one margin, but locally both margins are chilled against gabbro screens and larger gabbro dikes. The dikes generally grade into areas with dikes and pillow screens and in the Little Bay area into pillow lava with extensive dikes (Unit 2). The sheeted dike zones commonly develop rusty weathering scree slopes because of the abundant disseminated pyrite in them.

Unit 2 - Pillow Lava and Diabase Dikes

This unit varies from dominantly sheeted dikes with pillow screens in the contact area with the sheeted dikes to pillow lavas with extensive to common diabase dikes in other areas.

The Little Bay Head area and the area northeast of Little Ward's Harbour is characterized by extensive dikes. In the Little Bay Head area there are sections over 50 m that consist of multiple intrusions of medium grained diabase and gabbro dikes which are individually up to 2 m wide. Locally, these extensive dike sections are sheeted, *i.e.*, they possess one chilled margin. The dikes trend slightly east of north at a high angle to the enclosing pillow lava.

Unit 2 in the Halls Bay and Southern Arm areas is predominantly pillow lava with common diabase and gabbro dikes. These dikes have the same orientation and relationship to the pillow lavas as do the dikes described above.

The pillow lavas are fine grained to aphanitic, green to gray-green and equigranular. They are epidotized, generally with their cores completely replaced by epidote. There are local areas where chloritic alteration predominates, in particular in the shear zones that are developed in this unit. Quartz and calcite veining is common. The pillows are characterized by thin selvedges and are generally nonvesicular. They are closely packed and interpillow material is minor, although locally white, gray, and green interpillow chert is common. Interpillow aquagene tuff is rare. Minor horizons of pillow breccia and agglomerate are intercalated with the pillow lava. The pillows vary in size from 15 cm to 1 m and vary in shape from round to elliptical. They are quite commonly flattened and moderately elongated in the plane of deformation.

The dikes are fine to medium grained, green, equigranular diabase and gabbro. Epidote veins and patches are scattered throughout. The dikes vary from a few centimetres to about 2 m wide. They commonly are highly pyritic. In places the dikes are boudinaged.

Unit 3 - Pillow Lava

Unit 3 consists dominantly of pillow lava with common diabase and gabbro dikes. It does not differ substantially from Unit 2 and the distinction is subjective in many places. There appear to be fewer dikes of diabase and gabbro (see also Fleming, 1970). The unit generally grades into the 'black facies' of Marten (1971a, b) and commonly contains red chert in its upper parts. It is therefore interpreted to represent a higher stratigraphic level than Unit 2. It must be emphasized, however, that much of the lower parts of the unit could be, and probably is, equivalent to Unit 2.

The pillow lavas are fine grained to aphanitic, and locally medium grained. They are highly epidotized except for near the contact with Unit 6, where they are black and either fresh or chloritic. They are also chloritic in shear zones. The epidote occurs as veins, veinlets and patches and commonly completely replaces the pillow cores. The pillows vary in size from 15 cm to 1 m across. They vary from round and fan shaped to toed and tubular; some tubes are >10 m long. Interpillow material is generally common and consists of white and green chert and minor aquagene tuff and pillow fragments. Narrow discontinuous beds or lenses of aquagene tuff and agglomerate are locally intercalated with the pillow lava. The agglomerate-tuff consist of bombs with chilled rims and lapilli that range in size from <2 cm to 0.5 m in length and generally show evidence of preconsolidation deformation. A few of the larger bombs are feldspar-phyric. The matrix is fine grained to aphanitic tuff, some of which appears to be aquagene.

The gabbro and diabase dikes and sills are fine to medium grained, green and equigranular. Minor feldspar-phyric phases are present; however, they may be feeders to the overlying Western Arm Group. The dikes consist of plagioclase and pyroxene and are variably epidotized.

Porphyritic dikes are common in this unit and are rarely found elsewhere. They are particularly common in the Whalesback - Little Deer Mines area. They can be classified into four types containing, respectively, phenocrysts of feldspar, amphibole, amphibole and feldspar, and pyroxene in a green, aphanitic matrix. They intrude the Lush's Bight Group, but according to Fleming (1970) were metamorphosed and deformed with it. The dikes vary in width from several centimetres to several metres and trend generally either northwest or slightly east of north.

Unit 4 - Pillow Lava

The contact between Units 2 and 4 is gradational in the Little Bay area, the distinction between the two units being based on the extensive occurrence of variolitic pillow lava in Unit 4a and massive flows in 4b. Interpillow chert is also very common in Unit 4.

Unit 4a consists of fine grained to aphanitic, gray-green to dark green, equigranular pillow lava. The pillows are moderately to strongly epidotized, with the cores generally completely replaced by epidote. Quartz, calcite and epidote veins are common. Quartz veining is locally extensive. The thin rims are generally chloritic, and, as is common in all these units, form a chlorite schist envelope around the epidotized cores. Chlorite alteration is the pervasive type in the many shear zones. The pillows are closely packed with extensive gray, green and white interpillow chert in the area of the Little Bay and Sleepy Hollow Mines. Red chert occurs as a minor constituent throughout the unit. The pillows vary from <30 cm to 76 cm in size and are round to bulbous and elongate in shape with a flattening and slight stretching in the plane of the deformation. Quartz amygdules are also common in this unit. Minor breccia and pyroclastic breccia and rare agglomerate occur throughout the sequence.

The presence of variolites is a diagnostic feature of Unit 4a. Variolites, altered to epidote, are common in the Little Bay Mine area and are particularly well developed in the Shoal Arm area. The variolites are disseminated throughout the pillows but are locally concentrated either in the cores or near the rims of the pillows. In places, they are up to 1 cm across.

Laterally along strike to the northeast from both the Sleepy Hollow and Little Bay Mines, the basic volcanic rocks have been leached and silicified so that they are a white to whitish-green, siliceous rock. Minor quartz veins with pyrite and chalcopyrite cut these rocks. Disseminated pyrite is common. Fine to medium grained, equigranular, green diabase and gabbro dikes are common. They vary from a few centimetres to about 1 m wide.

The basic volcanic rocks (4b) constituting the top part of Unit 4 are not very variolitic, and massive flows, locally with poorly developed pillow structures, and large gabbro dikes and sills are common, particularly in the St. Patrick's area. These rocks are intercalated with normal pillow lava. The pillows are fine grained, green, equigranular and moderately to extensively epidotized. The massive flows and gabbro dikes and sills are fine to medium grained, green and equigranular. They consist of a saussuritized yellow-green feldspar and a chloritized mafic mineral. The gabbro dikes and sills vary from 1 m to 40 m in width. Locally vesicular and scoriaceous zones are developed. Fine grained diabase dikes intrude these rocks. Feldspar porphyritic dikes are locally present.

Unit 5 - Unseparated Lush's Bight Group

Large areas of pillow lava, basic intrusions and minor pyroclastics that have not been looked at in detail are herein referred to as Unit 5.

STRUCTURE

Early Structures

The Lush's Bight Group contains a single, fine grained foliation which trends northeast and dips steeply, generally to the northwest. This fabric is commonly nonpenetrative in the pillow lavas where it is restricted to the pillow margins or the matrix. It is an L-S fabric associated with a steep stretching lineation and is defined by chlorite and fibrous amphibole. This foliation is axial planar to major northeast trending and plunging folds. The study area appears to consist of the limbs of folds separated from each other by steep late faults.

Chlorite schist shear zones are widely developed in the Lush's Bight Group. They form elongated or lenticular zones, from a few metres wide to over 100 m wide, of coarse chlorite schist. These zones of strongly flattened rock pass into the normal weakly deformed host rocks with gradational contact. This gradation occurs over a metre to tens of metres depending on the width and intensity of the shear zone. The country rocks in these shear zones become totally schistose and it is generally difficult to determine the protolith. Dikes in these zones are transposed into the plane of deformation and in places boudinaged. The schist zones are not lithologically controlled, although they parallel stratigraphy, and are both mineralized and barren. However, the schist zones are generally more highly pyritized than the country rocks.

Kennedy and DeGrace (1972) demonstrated that the foliation in the chlorite schist zones is a composite fabric derived by folding and transposition of an earlier chlorite foliation. They further demonstrated that the chlorite schist zones resulted from the superimposing of a homogeneous deformational fabric on an older inhomogeneously developed fabric in shear belts. The regionally developed foliation in the Lush's Bight Group is thus the result of a second deformation (D_2).

Marten (1971b) mapped a series of faults having sinistral displacements subparallel to the regional foliation in the Western Arm area. He interpreted them to be slides related to the regional deformation. Kennedy and DeGrace (1972) also noted gently inclined faults, parallel to the trend of the regional foliation, separating various units of the Lush's Bight Group in the King's Point area. Similar faults can be seen on the Lush's Bight Group in the study area.

Late Structures

Crenulations of the regional foliation (S_2) can locally be seen. These crenulations are folded by kinks/flexures and by major open folds. These kinks/flexures and open folds are well developed in the chlorite schist zones where they fold the schist. They are rarely developed, or seen, outside of the schist zones. The axial planes dip steeply and trend approximately north-south. They are steeply plunging. The open folds do not affect the kinks/flexures and are interpreted to be contemporaneous with the kinks.

A number of post-folding, major faults transect the Lush's Bight Group in this area. The most prominent are the Deer Pond Fault, the Little Deer - Davis Pond Fault system, the Gull Pond Fault and the Sullivan Pond Fault. Numerous splays and subsidiary faults are related to them. Similar faults in the Western Arm area are believed to have dominant dextral strike-slip movements on account of their large horizontal components, straightness and lateral continuity (MacLean, 1947; Marten, 1971b). Similar dextral strike-slip movement is inferred for the faults in this area on the basis of movement along the Davis Pond Fault and the 4 km dextral offset of the Lobster Cove Fault (MacLean, 1947; Neale and Nash, 1963); however, a component of dip-slip movement is also present. Many of the faults appear to have cut out the axial zones of the major folds in the region. Narrow, less intense shear zones, breccia zones and brown carbonated breccia zones accompany the faulting.

MINERALIZATION

The Lush's Bight Group contains more base metal sulphide showings per square kilometre than any other group of rocks in Newfoundland (Dean, 1978). The group has been extensively prospected and two major mines, Little Bay and Whalesback, and about two dozen prospects have made this area the copper center of Newfoundland.

The many deposits differ greatly in size but all have several features in common which were noted by earlier workers. All are roughly ellipsoidal with their long axes approximately coplanar with bedding. They occur almost exclusively in chlorite schist shear zones developed in pillow lavas

(Peters, 1967). These schist zones are parallel to or conformable with the stratigraphy and the sulphide lenses conformable with the schist. They consist mostly of pyrite with lesser amounts of chalcopyrite, pyrrhotite and sphalerite and minor values of gold and silver.

Douglas, Williams and Rove (1940) and MacLean (1947) considered the deposits to be replacements of chlorite schists in the shear zones during late stages of faulting and thus to have a common origin. MacLean also concluded that there might be a genetic relationship between the sulphides and granodiorite in the area. Williams (1963) reasoned that a genetic relationship to volcanism might exist but that the final emplacement and distribution of sulphides postdated the volcanics and resulted from structural deformation. Kanehira and Bachinski (1968) concluded that the sulphide mineralization at least in part predated deformation and metamorphism but also must have postdated the end of volcanism. West (1972) concluded that the mineralization at the Little Deer mine was post-volcanic.

Kennedy and DeGrace (1972) considered the deposits to predate the main regional deformation (D_2) because pyrite bands are commonly folded about the associated folds and chalcopyrite is concentrated in fold hinges. Also in the Whalesback area the sulphides are cut by the predeformation porphyry dikes (Fleming, 1970). They also concluded that in most showings banding resembling layering is present and that with the exception of the Whalesback and Little Bay Mines the deposits occur in layered tuffaceous rocks. They thus concluded that the mineralization was syn-volcanic.

During the course of this study six old deposits and showings were looked at. They were the Hearn Gold Prospect, the Delaney prospect, the Sleepy Hollow Mine, Little Bay Mine, Whalesback Mine and Little Deer Mine. Unfortunately, there is not much to be seen on surface at most of the deposits and showings, except for old dumps. Two previously unreported showings were also studied. They are located near Bartletts Cove and at Bob Point near Halls Bay Head.

Hearn Gold Project

The Hearn Gold Prospect is located on the west side of Little Bay. The reader is referred to Snelgrove (1935) and MacLean (1947) for a detailed account of the exploration and development history of the prospect.

The prospect consists of sulphide- and gold-bearing quartz veins and disseminated pyrite in chlorite schist in the sheeted dike zone of an ophiolite. The contact with pillow lava is only a few tens of metres away and pillow lava screens are locally present. Shearing and chlorite schist are inhomogeneously developed and the pillow screens generally take up most of the deformation.

The mineralization occurs in a chlorite schist zone up to 2 m wide intermittently developed over a distance of a kilometre or more. The mineralization occurs as disseminations and veins, up to 2 cm thick, of pyrite in the schist. It also occurs in quartz ± calcite veins and veinlets containing pyrite, chalcopyrite, sphalerite, arsenopyrite, galena and gold in that order of abundance. There is no visible gold but it occurs associated with arsenopyrite, sphalerite and minor galena (Snelgrove, 1935).

Delaney Prospect

This prospect, consisting of a shaft and an old dump, lies immediately east of the government wharf at St. Patricks. MacLean (1947) gives an historical review of the prospect.

The prospect is in pillow lavas of Unit 4b. The mineralization occurs as disseminations, concentrated disseminations, and thin veinlets in chloritized and silicified pillow lava with common gabbro dikes. Quartz veining is common. The mineralization consists of pyrite, chalcopyrite, pyrrhotite, quartz and carbonate.

Sleepy Hollow Mine

The Sleepy Hollow Mine is located approximately 400 m south of the community of Little Bay and about 400 m west of the Little Bay Mine. See Douglas *et al.* (1940) and MacLean (1947) for a detailed account of the exploration history and geology of the mine.

Except for a number of shafts, broken rock from development and a few outcrops, there is little to see on surface. According to MacLean (1947) the deposits occur in two parallel chlorite schist zones that are derived from pillow lava. These schist zones are roughly parallel to the main shear zone at Little Bay Mine. Pillow structures with variolites, and interpillow chert and jasper are locally preserved in the schist zone. Sericite and quartz-sericite schist can be seen in rubble and mine waste and appears to be an alteration of basic rocks. Diabase dikes are common.

The mineralization occurs mainly in the form of massive lenses within the chlorite schist. Pyrite and chalcopyrite are the principal minerals. The mineralization, in particular pyrite, also occurs as disseminations in the chlorite schist.

On the coast at Shimmy Cove, approximately 1.5 km northeast along strike from the mine, the pillow lavas have a distinct yellowish-white alteration color due to leaching and silicification.

Little Bay Mine

The mine is situated on a peninsula approximately 0.75 km southeast of the community of Little Bay. Douglas *et al.* (1940), MacLean (1947) and Peters (1967) discuss the geology, exploration and production history of this mine. Between 1878 and 1892, Little Bay produced 103,000 tonnes of copper of 2.5-10% grade. In the period 1952-1969 it produced 2,500,000 tonnes of 2% copper (West, 1972).

The deposit(s) occur(s) in a chlorite schist zone in generally highly variolitic basaltic pillow lava with common diabase dikes. White and green interpillow material is common in this pillow sequence. Barren chlorite schist zones are also developed in the area of the mine. All of the schist zones are gradational into less deformed pillow lavas.

On the coast about 1.5 km northeast along strike a zone of intensely bleached and silicified pillow lava, breccia and agglomerate occurs. This alteration zone is best exposed near the old smelter site opposite Otter Island. The zone is approximately 400 m wide and extends for about 300 m to the southwest. Less intense and minor alteration of this type occurs along strike on the west and east coast of Otter Island, a distance of 1.5 km.

The pillow lavas are highly epidotized in the cores and the rims are chloritic. As the shear zone is approached the rims become chlorite schist enveloping an epidotized core, with common quartz and calcite veins and pods. Quartz amygdules are locally common.

The Little Bay deposits occur as massive lenses and pods, as veins and veinlets of pyrite and chalcopyrite and as sulphide-bearing quartz veins in chlorite schist. The mineralogy is pyrite, chalcopyrite, wurtzite, magnetite, marcasite, pyrrhotite and covellite (MacLean, 1947). Quartz is the principal gangue mineral. The schist zone has a mineralized length of about 300 m and a maximum width of 25 m.

In the glory hole at the old mine site, the mineralized zone within the chlorite schist is approximately 10 m wide. The mineralized zone consists of massive lenses, veins and disseminated sulphides. The massive zones are underlain by a 1 m thick zone of disseminated euhedral pyrite, thin pyrite veinlets and minor quartz veins in chlorite schist. In the chlorite schist there are small, irregular patches of white, sericite(?) schist that appear to grade into chlorite schist. This zone is overlain by a zone consisting of bands (or veins) of sulphide 1 cm to 15 cm thick with interbanded chlorite schist 0.5 cm to 5 cm thick. This zone is up to 5 m thick and consists mostly of pyrite with minor chalcopyrite and pyrrhotite. Chalcopyrite increases towards the top of this zone. These sulphide bands have cross-cutting relationships to the chlorite schist and many appear to be veins that are transposed coplanar with the chlorite schist.

Massive lenses, 40 cm to 1 m thick, of coarse, granular, grey pyrite and minor chalcopyrite in a quartz-rich gangue are locally present. These massive lenses have a streaky banding defined by pyrite and quartz-pyrite layers.

The hangingwall contact is marked by a dike or by disseminated and veined pyrite in chlorite schist.

Whalesback Mine

MacLean (1947), Peters (1967), Kanehira and Bachinski (1968) and Fleming (1970) all deal with various aspects of the geology of this area and/or the mine.

The Whalesback deposit occurs in a chlorite schist zone within pillow lava. Small interpillow pillows, minor breccia and lapilli tuff also occur in the pillow sequence. The pillow lava is fine grained, grey-green, nonvesicular and nonvariolitic. Epidote veining is common and quartz veins are locally abundant. White and green interpillow material is common. Amphibole, feldspar, amphibole-feldspar and pyroxene porphyritic dikes and gabbro/diabase dikes are common. Kanehira and Bachinski (1968) stated that the porphyritic dikes cut the schist zone and the sulphide ore.

The mineralization occurs as lenses, pods, veins and disseminations in the chlorite schist. In order of decreasing abundance the mineralogy is pyrite, chalcopyrite, pyrrhotite, sphalerite, mackinawite, pentlandite, magnetite, cubanite, galena and ilmenite (Fleming, 1970).

Little Deer Mine

West (1972) studied the structure and ore genesis of the Little Deer Mine and the reader is referred to his thesis of which the following is a summary.

The Little Deer Mine consists of a number of lenses and associated disseminated mineralization in chlorite schist derived from pillow lava and possibly minor pyroclastics. This chlorite schist shear zone parallels the Whalesback shear zone. The main ore zones consist of three lenses of medium grained, massive and disseminated pyrrhotite and chalcopyrite with minor pyrite and sphalerite. Fragments of chlorite schist in the sulphides are common. Other lenses to the southwest consist largely of pyrite and sphalerite with thin laminations. Pyrite laminae are from 1 mm to 7 mm thick and are interlaminated with chlorite schist containing disseminated pyrite.

The lenses are about 3 m thick and from 50 to 120 m wide. The hangingwall contact is sharp with no sulphide mineralization but the footwall contact is marked by disseminated chalcopyrite, pyrite and pyrrhotite veinlets up to 30 m from the massive sulphide lenses.

West (1972) concluded, "the sulphide lenses of the Little Deer deposit formed after the volcanism that produced the Lush's Bight Group pillow lavas, in a post-volcanic schist zone."

Bartlett's Cove

This showing occurs just to the north of Bartlett's Cove in a chlorite schist shear zone in pillow lava of the Lush's Bight Group. Leaching and alteration of the chlorite schist also marks this schist zone. The mineralization occurs as 'veins' of sulphide 3 cm thick and 30 cm.long. The 'veins' are interpillow material between flattened pillows. The mineralization also occurs associated with carbonate in fractures, joints and along shear planes. Pyrite and minor chalcopyrite constitute the sulphide minerals.

Bob Point, Halls Bay Head

This showing occurs in mafic volcanics of the Cutwell Group near Halls Bay Head. It consists of pyrite as disseminations and as a vein 5 cm thick by 60 cm long.

SUMMARY AND CONCLUSIONS

The Lush's Bight Group consists of a number of fault-bound blocks, some of which contain an identifiable ophiolite stratigraphy. Chlorite schist zones within this sequence are early structures, are not lithologically controlled and are both barren and mineralized. The mineralization may have acted in part as zones of weakness along which shear zones developed.

The major sulphide deposits and showings in the Lush's Bight Group occur within chlorite schist zones. The schist zones are generally within pillow lava and/or intercalated pyroclastics and are conformable with the enclosing rocks. The sulphide lenses are in turn conformable with the schist zones, although sulphide veins crosscut the chlorite schist.

The mineralogy is simple and commonly there is a sharp hangingwall contact and a gradational footwall contact. Deformation has obliterated all primary structures and the sulphides are remobilized and recrystallized. Therefore, any paragenesis or mineral zoning is suspect.

There are several theories for the origin of these deposits, but the following evidence from this study suggests a syngenetic volcanic origin for the deposits: (a) they have an early, predeformational origin; (b) they are essentially conformable bodies in mafic volcanics of ophiolite affinity, *i.e.* they are stratabound; (c) they possess a simple mineralogy that is similar to volcanogenic ophiolite deposits; and (d) the chlorite schist shear zones are interpreted as early tectonic features that did not control mineralization. However, there is no doubt that the deposits have been remobilized and recrystallized.

The deposits differ from the Betts Cove Mine (ophiolite deposit) in that they do not occur at the sheeted dike - pillow lava contact. However, they do occur at a similar stratigraphic position and in rocks similar to the well preserved ophiolitic sulphide deposits at York Harbour (Duke and Hutchinson, 1974).

The chlorite schist shear zones have generally been considered as 'controls' for mineralization. However, chlorite schist zones also occur in the pillow lavas that overlie the sheeted dikes of the Betts Cove Ophiolite Complex (Douglas *et al.*, 1940; Upadhyay and Strong, 1973). Primary volcanogenic sulphide mineralization at the pillow lava - sheeted dike contact has been remobilized and redistributed along the schist zones (Kennedy and DeGrace, 1972). Duke and Hutchinson (1974) also described chloritic shear zones in the York Harbour mine area. They attributed them to late movement along a synvolcanic fault-fissure that controlled the distribution of ore deposition. However, the chlorite schist shear zones are conformable to stratigraphy and as such were probably flat zones at the time of their formation. The schist zones are thus interpreted as early shear belts which were initiated at points of greatest mechanical weakness, commonly, but not exclusively, the sulphide bodies. A similar conclusion was reached by DeGrace (1971) and Kennedy and DeGrace (1972) for the Lush's Bight Group in the King's Point area.

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MAJOR SULPHIDE MINERALIZATION IN THE AREA

1. Little Bay Head: Pyrite, chalcopyrite, pyrrhotite, sphalerite, arsenopyrite and marcasite in chlorite schist derived from pillow lava. Common diabase dikes.

2. Shoal Arm: Same as Little Bay Head.

3. Bartlett's Cove: Pyrite and minor chalcopyrite as stringers and associated with calcite veins in chlorite schist derived from pillow lava.

4. Hearn Prospect: Pyrite, chalcopyrite, sphalerite, arsenopyrite, galena and gold in quartz veins and as stringers and disseminations in sheared sheeted dikes with minor pillow screens.

5. Sleepy Hollow: Pyrite and chalcopyrite in chlorite schist within pillow lavas and minor diabase dikes.

6. Little Bay Mine: Pyrite, chalcopyrite, pyrrhotite and magnetite as massive lenses and pods, as stringers and disseminations in chlorite schist within pillow lava and diabase dikes.

7. Whalesback Mine: Pyrite, chalcopyrite, pyrrhotite and sphalerite as disseminations, stringers and banded lenses and pods in chlorite schist in pillow lavas. Mackinawite, pentlandite, magnetite, cubanite, galena and ilmenite are also present.

8. Little Deer Mine: Pyrite, chalcopyrite, pyrrhotite and sphalerite as disseminations, stringers and lenses and pods in chlorite schist in pillow lavas.

9. Duck Pond: Pyrite and chalcopyrite and sphalerite in chlorite schist in pillow lava.

10. St. Patrick's: Pyrite and chalcopyrite in chlorite schist derived from pillow lava and diabase dikes.

11. St. Patrick's Southwest: Pyrite and chalcopyrite as disseminations and in quartz veins in pillow lava and gabbro dikes and sills.

12. Delaney Prospect: Pyrite, chalcopyrite and pyrrhotite stringers and disseminations in silicified zone within pillow lava and diabase dikes. Quartz veining is extensive.

13. Lady Pond Mine: Pyrite, chalcopyrite and pyrrhotite in a series of lenses in chlorite schist in pillow lava and diabase dikes.

14. Sullivan Pond: Pyrite, chalcopyrite and minor sphalerite in chlorite schist.

15. Bob Head: Pyrite and chalcopyrite in quartz and calcite veins in chlorite schist.

16. Indian Head: Disseminated pyrite and chalcopyrite in a silicified schist zone in sheeted diabase dikes.

17. Indian Beach: Pyrite, chalcopyrite and pyrrhotite in a chlorite schist zone in sheeted diabase dikes. Possible pillow lava screens.

18. Bob Point Showing: Disseminations and stringers of pyrite and rare chalcopyrite in mafic volcanics, dikes and sills.

THE BETTS COVE SULPHIDE DEPOSIT

by

C.M. Saunders

Introduction

During the 1982 field season detailed mapping and sampling of the abandoned Betts Cove Mine was carried out as part of a masters thesis on the controls of mineralization there. The thesis will concentrate on the alteration surrounding the mine and its relationship to the mineralization, and on the ore mineral paragenesis. Upadhyay (1973) mapped the entire Betts Cove ophiolite and Riccio (1972) mapped the area between Burton's Pond and Betts Big Pond. The thesis area is within the region mapped at 1:50,000 by DeGrace *et al.* (1976). This study was confined to detailed mapping on a grid spaced in part at 50 x 25 m intervals and in part at 100 x 25 m intervals over the mine area and the Fault Cove Fault (Fig. 1), and relied on previous mapping when sampling showings away from the grid. Many geographical names were taken from Upadhyay's (1973) map as these names are on file with the Mineral Occurrence Data System.

The Betts Cove ophiolite, which is exposed in an arc extending from Betts Cove to Tilt Cove (Fig. 1), is a part of the Lower Ordovician Snooks Arm Group. The ophiolitic rocks are conformably overlain by volcanic and sedimentary rocks of disputed affinity which complete the Snooks Arm Group. The latter sequence has been interpreted as an early arc assemblage (DeGrace *et al.*, 1976; Strong, 1977) and as having formed in a marginal basin (Upadhyay and Neale, 1979). Jenner and Fryer (1980) favoured the latter interpretation or an oceanic island setting but were unable to distinguish between the two. The Snooks Arm Group is 5.7 km thick and has a southeasterly dip that varies from about 35° to 85° (Upadhyay, 1973). Rocks of ophiolitic affinity which outcrop further south from Nippers Harbour to Stocking Harbour are considered to be an extension of the Betts Cove ophiolite (Riccio, 1972; Upadhyay, 1973; DeGrace *et al.*, 1976). Upadhyay (1973) has divided the Snooks Arm Group into five formations, of which the lowermost is the Betts Cove ophiolite, and he has divided the ophiolite into four members - a layered Ultramafic Member, an irregular, poorly developed Gabbroic Member, a Sheeted Dike Member and a Pillow Lava Member. A complete section is exposed at Betts Cove but throughout most of the ophiolite the Pillow Lava Member is faulted against the Ultramafic Member and most of the two intervening members are missing.

The mine is located at Betts Cove in the contact zone between the pillow lava and sheeted dike units. Access is generally available by boat from Nippers Harbour, 7 km to the southwest. The Betts Cove Mine was in operation from 1875 to 1883 when it was closed as the result of a cave-in. During that time 130,682 tons of ore and regulus plus 2,450 tons of pyrite were produced, of which 95,999 tons of ore were shipped. The grade is said to have averaged nearly 10% copper. No estimate of reserves is available (Snelgrove and Baird, 1953).

Snelgrove (1931) and Baird (1948) described the sulfides at Betts Cove, and Upadhyay and Strong (1973) interpreted the deposits as comparable with those in Cyprus. In addition there are various unpublished company reports on the deposit.

Gabbro Member (Unit 1)

The largest mass of gabbro outcrops in the area northwest of Joey's Pond where it is faulted in part against

Contribution to Canada-Newfoundland co-operative mineral program 1982-84. Project carried out by Newfoundland Department of Mines and Energy.

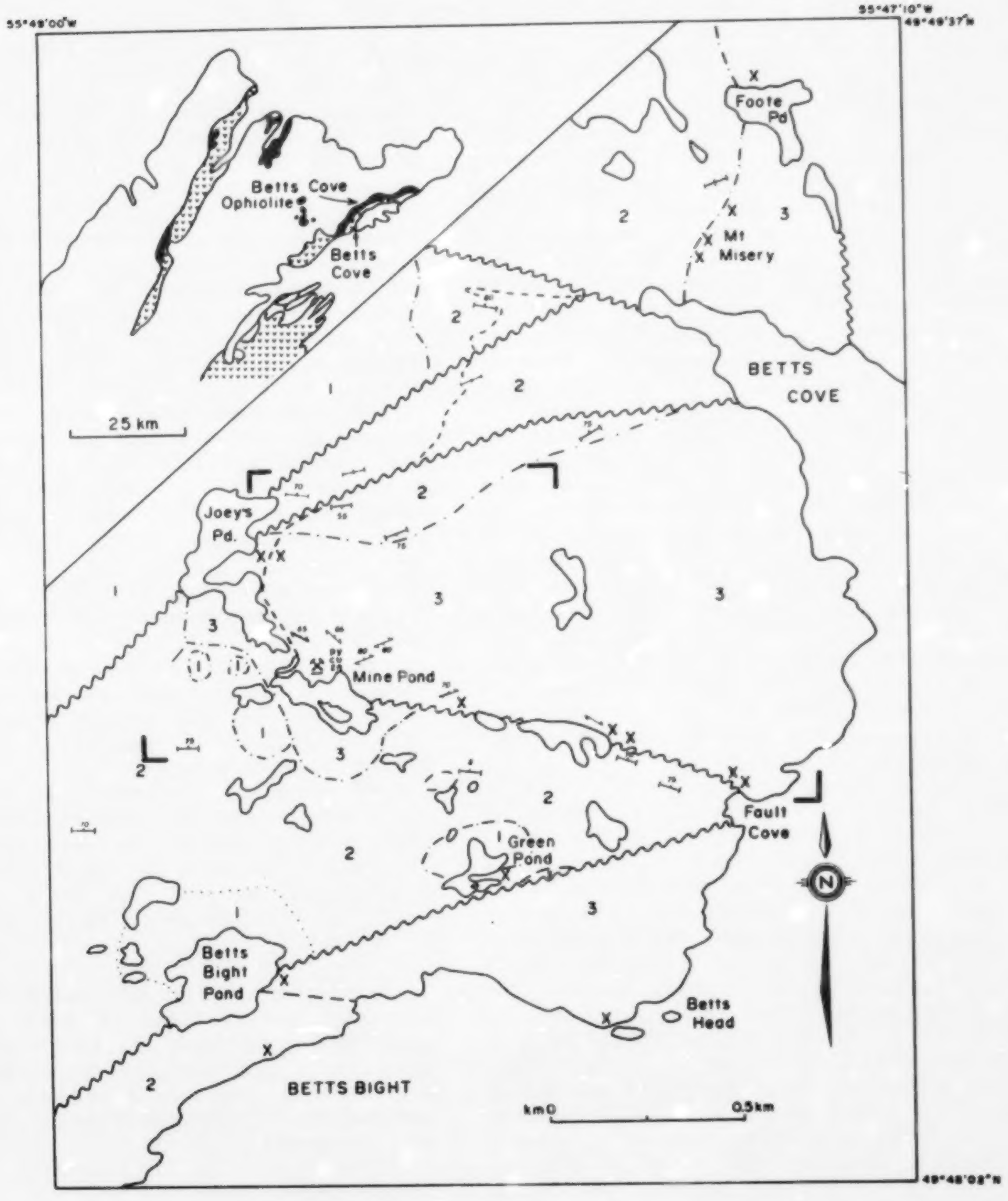
55°49'00"W
55°47'10"W
49°49'37"N
Betts Cove Ophiolite
Betts Cove
25 km
Foote Pd
Mt Misery
2
3
BETTS COVE
1
2
2
Joey's Pd.
1
3
3
3
Mine Pond
1
1
1
3
2
2
Green Pond
Fault Cove
N
Betts Bight Pond
3
Betts Head
2
BETTS BIGHT
km 0
0.5 km
49°48'08"N

Figure 1: Geology of the Betts Cove area, northern Newfoundland. Index map of Figure 1 shows location of the Betts Cove ophiolite and other ophiolites of the Burlington Peninsula (Strong, 1982).

3 Variolitic pillow lavas, pillow breccia.

2 Sheeted dikes with gabbro screens and minor pillow lava screens, minor dike breccia.

1 Fine grained gabbro and leucogabbro.

└ Corners of grid

- - - Betts Cove mine trail

sheeted dikes. However, to the northeast it is in gradational contact with the sheeted dike unit. Here, screens of gabbro and banded ultramafic rocks are found between the dikes. This gabbro, which was not mapped in detail, consists of approximately 50% plagioclase, 40% mafic minerals and up to 10% quartz. Grain size averages 1 to 2 mm.

To the west and south of the mine area, numerous screens and several large pods of gabbro occur within the sheeted dikes. The largest pods outcrop west of Mine Pond and along the north side of Green Pond. They are cut by dikes which become more numerous towards the edges of the gabbro pods until they become sheeted. The large mass north of Betts Bight Pond, mapped by Upadhyay (1973), and Riccio (1972), was not mapped by the author. Generally the gabbro contains about 50% mafic minerals and variable amounts of plagioclase and quartz. The plagioclase is translucent to opaque, and forms white, irregular patches which surround and enclose the pyroxenes. Most of the plagioclase has been variably altered to sericite. Plagioclase from gabbro near Fault Cove has been extensively altered, (probably saussuritized). The gabbro near Green Pond is leucocratic, containing about 80% plagioclase and quartz and 20% highly altered pyroxene. In places subhedral 2 mm crystals of plagioclase are partly surrounded by patches of altered chloritic pyroxene.

These gabbro pods may have intruded the sheeted dike and pillow lava units and been subsequently cut by dikes. The only definite intrusive contact was found on the shoreline at Betts Cove. There, a quartz-rich calcareous gabbroid rock intrudes the sheeted dike unit. In a sample taken from a boulder in which the contact is displayed, the gabbroid rock is chilled against the diabase. It contains 2 mm to 1 cm size xenoliths of diabase. In two places, screens of gabbro and pillow lava are found in close proximity within the dikes, suggesting that the gabbro may have intruded the pillow lavas.

Sheeted Dike Member (Unit 2)

The Sheeted Dike Member outcrops north, west and south of the central block of pillow lavas. The dikes strike generally east-west and dip steeply north, but their attitude varies locally, especially where there is a high percentage of gabbro screens. The dikes northeast of Joey's Pond are mostly sheeted, although there are numerous gabbro screens near the gradational contact with the gabbro unit. Dikes west of Joey's Pond and south of the Fault Cove Fault contain numerous screens and pods of gabbro. The dikes average 20 to 30 cm in width and weather red, red-brown, gray and green. Many of the red-weathering dikes are rich in mafic minerals (relative to the green weathering dikes) and the mafic minerals in places are aligned parallel to the dike margins. These dikes are fine grained and may be black on fresh surface but more commonly are olive green. The gray and green weathering dikes are generally fine grained and dark green to black on fresh surface, and plagioclase can be distinguished in most. Several thin, aphanitic, green-weathering dikes are also seen. These are commonly chilled against the other dikes which they generally cut at low angles.

Several east-west trending, very fine grained, siliceous dikes cut the pillow lavas north of Fault Cove. These dikes weather white and are pale green on fresh surface.

There are several orange-red weathering, variolitic dikes outcropping on Mount Misery. The variolites average 3 to 5 mm, weather white, and are prominent on weathered surfaces. They are translucent brownish green, have diffuse margins and are of a more felsic composition than the matrix which is fine grained and black. Some of the variolites are zoned such that the rims are richer in quartz and, therefore, more resistant than the centers. This gives rise to a doughnut effect on weathered surfaces.

A late siliceous dike cuts, at right angles, sheeted dikes along the Betts Cove mine trail. This dike is 40 cm wide, aphanitic, brownish yellow and has approximately 1%, 1 mm patches of white calcite.

Most dikes have at least one chilled margin although the contacts are commonly obscured by fracturing and shearing. The red weathering dikes are in places chilled against the green-gray weathering dikes but the reverse is also common.

Dike breccia outcrops in several areas. It commonly follows the trend of the dikes and consists of subrounded to subangular fragments which average a few millimetres to a few centimetres across, but in places are up to 30 cm across. The degree of brecciation varies, and in places fragments are all diabase and are difficult to see on fresh surface. Where brecciation has been more intense there is a higher proportion of matrix, and fragments of gabbro have been incorporated into the breccia. Some of the diabase fragments have chilled margins indicating that the dike had cooled before it was brecciated. The matrix is composed of smaller fragments and a yellow epidote cement.

Pillow Lava Member (Unit 3)

The pillow lavas are found in three areas; Mount Misery, to the immediate north of Betts Cove; south of Betts Cove, in the vicinity of and to the east of the mine; and on the coast near Betts Head. They generally dip moderately eastward. They average 10-30 cm in diameter, but may be 50 to 100 cm wide in places. Most are round or ellipsoidal; tubular pillows are also found, especially about 1 km east of the mine. Near the mine the pillows are tightly packed and there is little interpillow material. Away from the mine area there is interstitial green to pale brown and, less commonly, red chert. Red chert is more common on Mount Misery. Brecciated and broken pillows and hyaloclastic material are found in interstices where pillows are less tightly packed. Pillows are generally variolitic throughout the area, although in the vicinity of the mine at the gradational contact with the dikes they may contain only a few variolites. Variolites average 2 to 4 mm in diameter, but range from 1 to 7 mm. Commonly, variolitic texture begins 2 to 4 cm from the pillow rim and variolites increase in size and abundance towards the pillow centre until they coalesce. The variolites are lighter colored than the matrix, and most are pale green although they may also be cream, gray or brown. In places they are composed of acicular crystals (possibly amphibole) arranged in radial clusters. The matrix to the variolites is usually fine grained and gray to black. In places pillows are pale green to gray and this may be the result of alteration or may represent completely coalesced variolitic material. The pillows are locally amygdaloidal, and vesicles are filled with calcite, chlorite or quartz.

Near the mine and the nearby ponds the contact between the pillow lavas and the dikes is gradational. The pillows are small, poorly developed and tightly packed. They contain few variolites and are cut by pyrite and chalcopyrite-bearing stockwork quartz. Outcrops along the lake shores and the old road are generally unpillowed, fine grained black basalts. In places, dikes with pillow screens are seen.

Pillow breccia occurs locally in the area. It consists of subangular fragments up to several centimetres across, in a chloritic, epidotitic or siliceous matrix. Locally hyaloclastic texture is well developed. Pillow brecciation is in places confined to interstices, but is also developed on a larger scale.

Throughout the area the pillows are cut by late vuggy quartz veins which commonly contain epidote and calcite.

Economic Geology

Rocks outcropping in the vicinity of the mine contain only minor sulfides and the underground workings are now inaccessible. Much of the immediate area is covered by debris from the rockfall that resulted in mine closure, and by ore and waste dumps. At the mine site most of the sulfide in outcrop is stringer pyrite and chalcopyrite in stockwork quartz, and pyrite disseminations in the pillow lavas. These occurrences are concentrated in chloritic shear zones striking southeast and dipping 60° to 70° northeast. In places the pillows are sheared and flattened. Pyrite and chalcopyrite, associated with sugary white quartz, are locally concentrated in the interstices.

Massive sulfide outcrops at only one place; a 1.5 m thick unit of massive banded sulfide intercalated with sheared chloritic pillow lavas outcrops at the entrance to, and for the length of, a 20 m long adit. The shear zone is 3 to 4 m wide, strikes 060° and dips 70°N to 80°S. The banding in the ore, which parallels the foliation of the shear zone, may be of sedimentary origin, but no unequivocal sedimentary features were seen. The bands are 1 to 5 mm thick and are composed of pyrite, very fine grained sugary quartz, and minor chalcopyrite. The sulfide zone is very soft, crumbly and porous. This is not a result of surface weathering as the rock is not rusty. The banding appears to be the result of differing grain sizes and textures of pyrite and differing proportions of quartz and pyrite. The sulfide zone has a sharp contact with the sheared pillows and contains lenses and fragments of them. The pillows are variolitic and near the sulfides have well developed hyaloclastic texture. Red chert is found in the interstices and is in places remobilized in stringers which parallel the foliation.

Several showings were visited other than those in the immediate vicinity of the mine. All are either stockwork quartz with pyrite and chalcopyrite, calcite veins with chalcopyrite, or minor disseminations of chalcopyrite and pyrite. The most important showings occur at Mount Misery, along the Fault Cove Fault, at Betts Head and at Betts Bight Pond. An abandoned shaft or test pit is located at each of these showings. Most have only minor sulfides in outcrop, but strewn about there are mineralized boulders and rubble from inside the shafts. All of these showings except the one at Betts Head are near the pillow lava - sheeted dikes contact, but at Betts Head there are numerous dikes cutting the pillows.

Upadhyay (1973) estimated the proportion of dikes here to be 10% to 30%. Chloritic shear zones were seen in outcrop at only a couple of places along the Fault Cove Fault and at Betts Head but boulders from other showings are chloritic and sheared. Many barren shear zones, as well, are found in the pillow lava unit along the Fault Cove Fault. The shear zones strike generally east-southeast, parallel to the fault, and dip steeply north. The shear zones range from a few centimetres to a couple of metres in width and die out rapidly across their strike. Upadhyay and Strong (1973) interpreted them as being later than the mineralization and thought that the mineralized zones were structurally weak areas that were preferentially sheared.

Samples (especially of massive sulfide) were collected from ore dumps in the area. Many massive sulfide samples are composed of bands of pyrite, chalcopyrite and sphalerite. In many samples the sulfides are sheared and the banding appears to be overprinted by secondary subhedral pyrite cubes. Chalcopyrite is also found as irregular bands in chlorite schist. These samples contain only minor subhedral pyrite. Most of the stringer and disseminated sulfides were sampled from outcrops around the mine and the showings previously described. The quartz stringers are generally thin (<5 mm across) and contain stringers and disseminations of chalcopyrite. Pyrite is also commonly present in the stockwork and disseminated in the rock as subhedral to euhedral cubes up to 5 mm across. In places, stringers and patches of pyrite are found without chalcopyrite or quartz as accessories. Chalcopyrite and malachite are found in later, thin calcite veins which cut the massive ore.

The showing at Burton's Pond, which is about 1 km west of the area shown in Fig. 1, was examined briefly. It is in the sheeted dike unit but there are a large number of gabbro and ultramafic screens in the area. The rock around the showing is extensively chloritized and is cut by quartz and calcite veins. The sulfides occur as stringers and disseminations in quartz veinlets.

The showing was described briefly by Douglas *et al.* (1940). Arsenopyrite was tentatively identified and a grab sample was analyzed with the following results: Cu 1.21%, S 3.36%, As 2.68%, Ag 10.6 g/t and Au 14.4 g/t. The high arsenic value was interpreted as a confirmation of the presence of arsenopyrite (Douglas *et al.*, 1940).

The present author was influenced by this report and wrongly identified the most common sulphide at the showing as arsenopyrite (reported in the Newfoundland Department of Mines and Energy Preliminary Reports for 1982). It was later identified in polished section and by electron microprobe as non-magnetic pyrrhotite. A few microscopic grains of cobaltite (CoAsS) were identified by microprobe analysis. Other sulphides present are chalcopyrite and minor sphalerite.

Acknowledgements

I wish to thank Career Oriented Summer Employment Program for funding, Anne Hogan for field assistance, Paul Dean, Baxter Kean and Dave Strong for supervision and Wayne Ryder, Sid Parsons and Jim Barrett for logistic support. Jim should be given a medal for his patience with our van. A special thank you to the people of Nippers Harbour.

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MINERAL OCCURRENCE DATA SYSTEM

by

C.F. O'Driscoll

INTRODUCTION

The Mineral Occurrence Data System project was initiated in 1978 (McArthur, 1978; Missan *et al.*, 1979). It is designed to offer an efficient information service on all mineral occurrences in the province to geoscientists in exploration, government and academic research. It is a two-part project comprising a manual Mineral Inventory File and a computerized Mineral Index.

MANUAL MINERAL INVENTORY FILE

The manual Mineral Inventory File is part of the National Mineral Inventory and was originally proposed to continue and update the card system of Hsu (1974) and the mineral occurrence maps and tables of Douglas (1976a and b).

In 1978 a pilot project was carried out in the Stephenville (12B) map area. By April, 1979, the system was fully operational with two Mineral Inventory Geologists (one responsible for insular Newfoundland and one for Labrador) and one Project Geologist. The number of Mineral Inventory Geologists increased to a maximum of four during 1981.

Prior to 1978, information on the geology, history of exploration, nature of mineralization and other important data on mineral properties could only be obtained by long research through numerous files and publications. With the Mineral Occurrence Data System in place, this preliminary research can now be done quickly and efficiently. So far approximately 70% of the Province's mineral occurrences have been documented. It is hoped to have cards for all occurrences completed and mineral occurrence maps published within the next fiscal year.

A Mineral Inventory "card" or file consists of up to four pages (or more, depending on the amount of data available) which summarize all the available information on a known mineral occurrence. A card may be used for any type of occurrence from an indication to a producing mine. In preparing a card, the geologist researches all reports and publications which contain information on a particular occurrence. The location is then plotted on a 1:50,000 or 1:250,000 scale topographic map and the information is condensed under the headings: description, history of exploration and development, production and/or reserves, status, type of deposit, mineralogical composition, nature of mineralization and genesis, host rocks, structure, metal/mineral content, geophysical expression, geochemical expression, physiographic setting, remarks and references. These cards are then placed on file and are available for anyone to use if data is not confidential. Confidential cards are filed separately.

To date, information on approximately 2,500 mineral occurrences has been compiled. When cards are completed for an NTS area, the occurrences are plotted on maps with updated geological bases and published. Mineral occurrence maps (1:250,000) have been published for NTS areas 12B (Stephenville), 2E (Botwood) and 14C (Nain). It is our objective to publish maps for all areas of the Province at appropriate scales. For the most part, they will be published at 1:250,000, but in areas which require more detail, the scale will be larger. It is planned to have

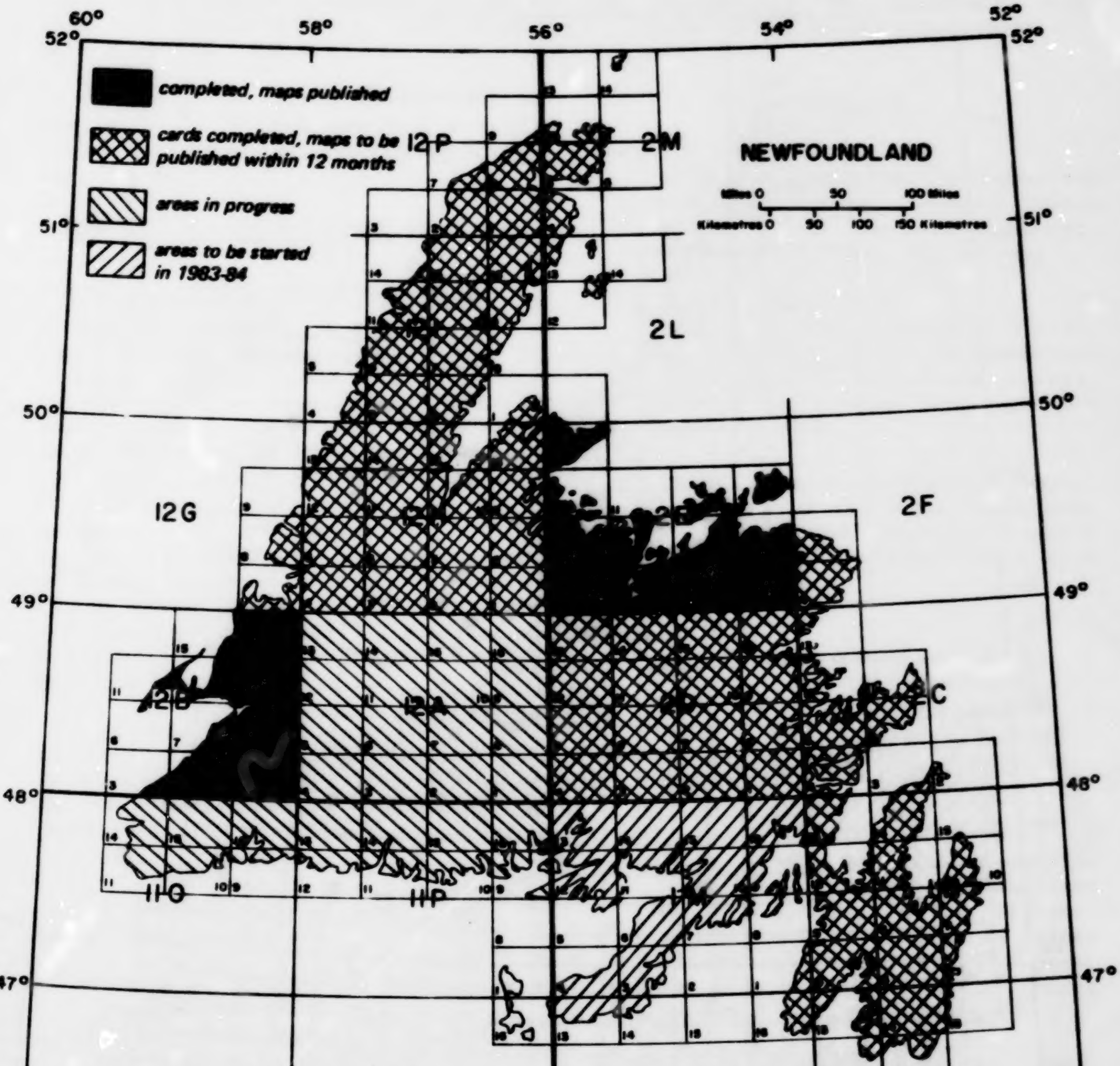
completed, maps published
cards completed, maps to be published within 12 months
areas in progress
areas to be started in 1983-84
NEWFOUNDLAND
Miles 0 50 100 Miles
Kilometres 0 50 100 150 Kilometres
60°
58°
56°
54°
52°
52°
51°
50°
49°
48°
47°
46°
12P
2M
2L
12G
2E
2F
12B
12A
2C
11O
11P
1M
11I
1L
1K

FIGURE 1: *Index map for Mineral Occurrence Data System project, insular Newfoundland.*

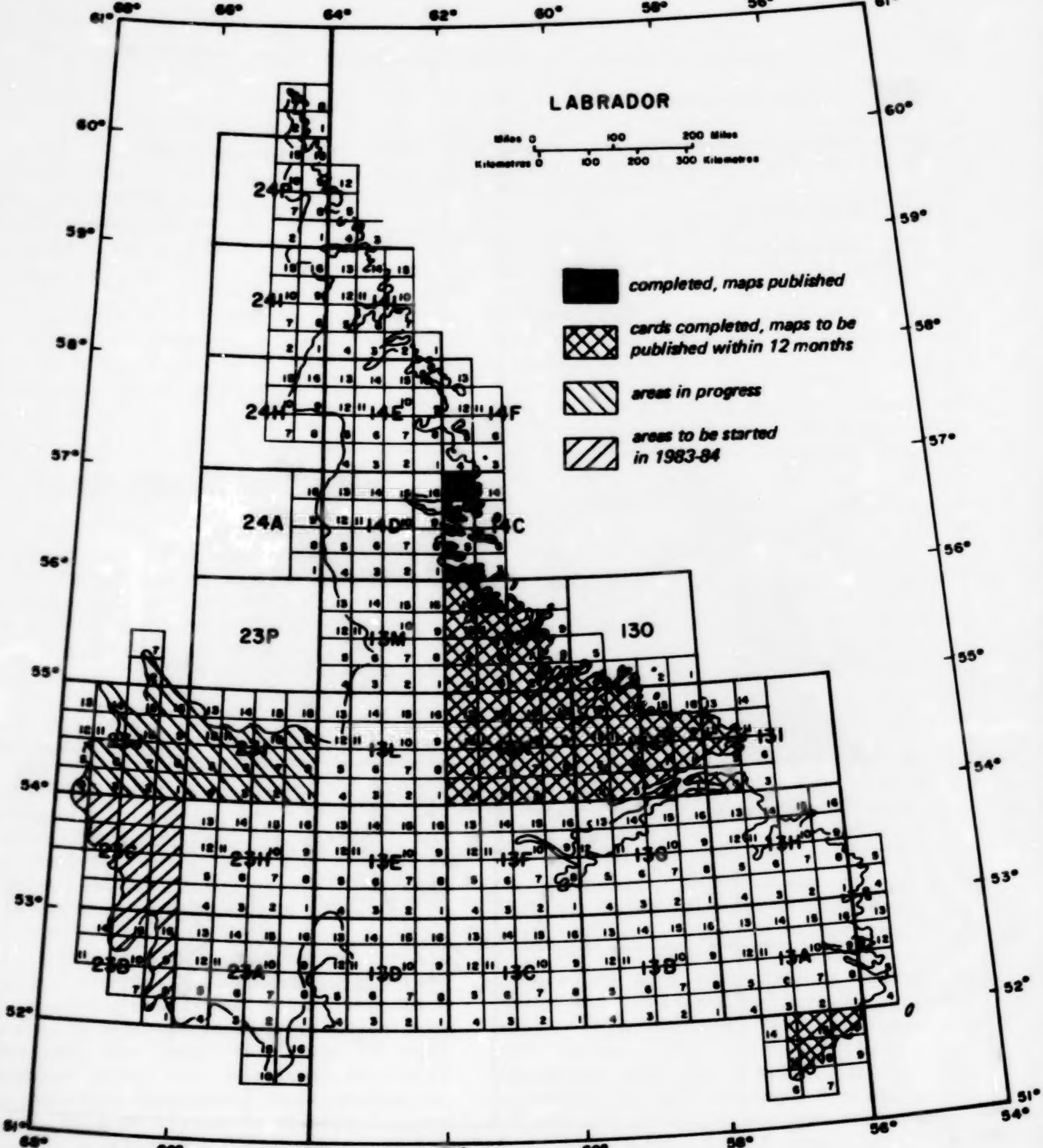

FIGURE 2: *Index map for Mineral Occurrence Data System project, Labrador.*

maps published on the following areas by the spring, 1983: 1[illegible] (Snegamook Lake), 13K/5 (Wuchusk Lake), parts of 13J and O (Rigolet and Makkovik), 12H (Sandy Lake), and 13N (Hopedale).

Mineral inventory cards will be available on microfiche for mineral occurrences on all published maps within the next year.

COMPUTERIZED MINERAL INDEX (Missan *et al.*, 1979)

The computerized Mineral Index is the additional part of the system and contains coded and free format data on mineral occurrences selectively extracted from the manual Mineral Inventory File. The purpose of the index is to organize efficiently important data on the occurrences so that a wide variety of retrievals can be made taking advantage of the powerful sorting capabilities offered by computerization. To manage the file, a computer program called GRASP (Bowen and Botbol, 1975) was installed on an IBM 370 computer at Newfoundland and Labrador Computer Services Limited.

By the use of computers, the retrieval capability from the data bank is optimized and complex retrievals can be made which would be virtually impossible if a manual inventory system were used.

Some examples of the types of possible retrievals are:

1. Listing all mineral occurrences in a geographical area;
2. Listing combinations of commodities which occur in particular environments;
3. Listing factors such as stage of exploration, production status, etc., for commodities in a geographical area;
4. Listing references for a particular occurrence or group of occurrences in a defined area;
5. Identification of mineral deposits with certain characteristics of mineralogy or lithology, *e.g.* Mississippi Valley-type deposits.

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SURFICIAL AND GLACIAL GEOLOGY
RECONNAISSANCE SURVEY OF PART OF THE GREAT GULL POND MAP AREA (12H/1), NEWFOUNDLAND

by

D.G. Vanderveer

INTRODUCTION

In reviewing the available data on (a) glacial dispersion (b) the extent of overburden and (c) the presence of significant mineralized boulders of unknown source in the Great Gull Pond map area, the author undertook a brief field reconnaissance of the area during the 1982 field season. The area visited (bounded by South Brook, the CN railway and the Trans Canada Highway) is extensively mantled with overburden. The main aim of the survey was to evaluate the information contained in a M.Sc. thesis (O'Donnell, 1973) with respect to the direction(s) of glacial dispersion and the glacial stratigraphy in the area.

Mineral claims in the area as of October 18, 1982, were held by Rio Tinto, Brinex Ltd., Pacific Coast Mines and Lewis Murphy. In addition, parts or all of three Reid Lots, Charter lands to ANDCO (Abitibi-Price), and a concession to Brinco cover portions of the map area. Over 50 per cent of the area is Crown Land, available for claim staking.

STRATIGRAPHY

Glacial stratigraphy in the sand and gravel pit at the Gullbridge Mine site reveals approximately 4 to 6 m of compact lodgement till overlying 8 to 10 m of gravel and sand with an occasional silt lens. The extent of the outwash deposit was not determined by the reconnaissance survey but the elevation of the top of the outwash (base of the lodgement till unit) is approximately 32 m (± 5 m) above the level of Great Gull Pond (at an approximate elevation of 150 m). It was not possible to determine the amount of sand and gravel removed by glacial erosion nor was it possible to locate any till unit below the sand and gravel. O'Donnell's thesis does not mention the occurrence of till over outwash.

GLACIAL STRIAE

Observed striae record two glacial flow directions. The most recent was towards the north or northeast (350 to 030 azimuth), but some outcrops have striae which indicate an earlier northeastward to eastward flow (030-090). The relation of the two glacial flow directions to the glacial till deposits and the sand and gravel has not yet been determined.

CONCLUSIONS

Glacial dispersion in the Great Gull Pond area may have been affected by two glacial flows, an early northeastward to eastward flow followed by a later northward to northeastward flow.

The presence of lodgement tills over deposits of sand and gravel have been confirmed at three widely separated geographic areas (namely, Tulk's River, Buchans, and Gullbridge) within the Central Volcanic Belt (Vanderveer and Sparkes, 1982, and Sparkes, this volume). The advance (or readvance) of ice mass(es) that deposited the upper till unit(s) may have been related to a widespread glacial event, indicating that other occurrences of glacial stratigraphy (*i.e.* till over outwash over till) may be expected throughout this region of Newfoundland.

The presence of two till units (one unit presumably underlying the sand and gravel deposit) and of till overlying sand and gravel (that often contains lenses of silt) and the distribution of

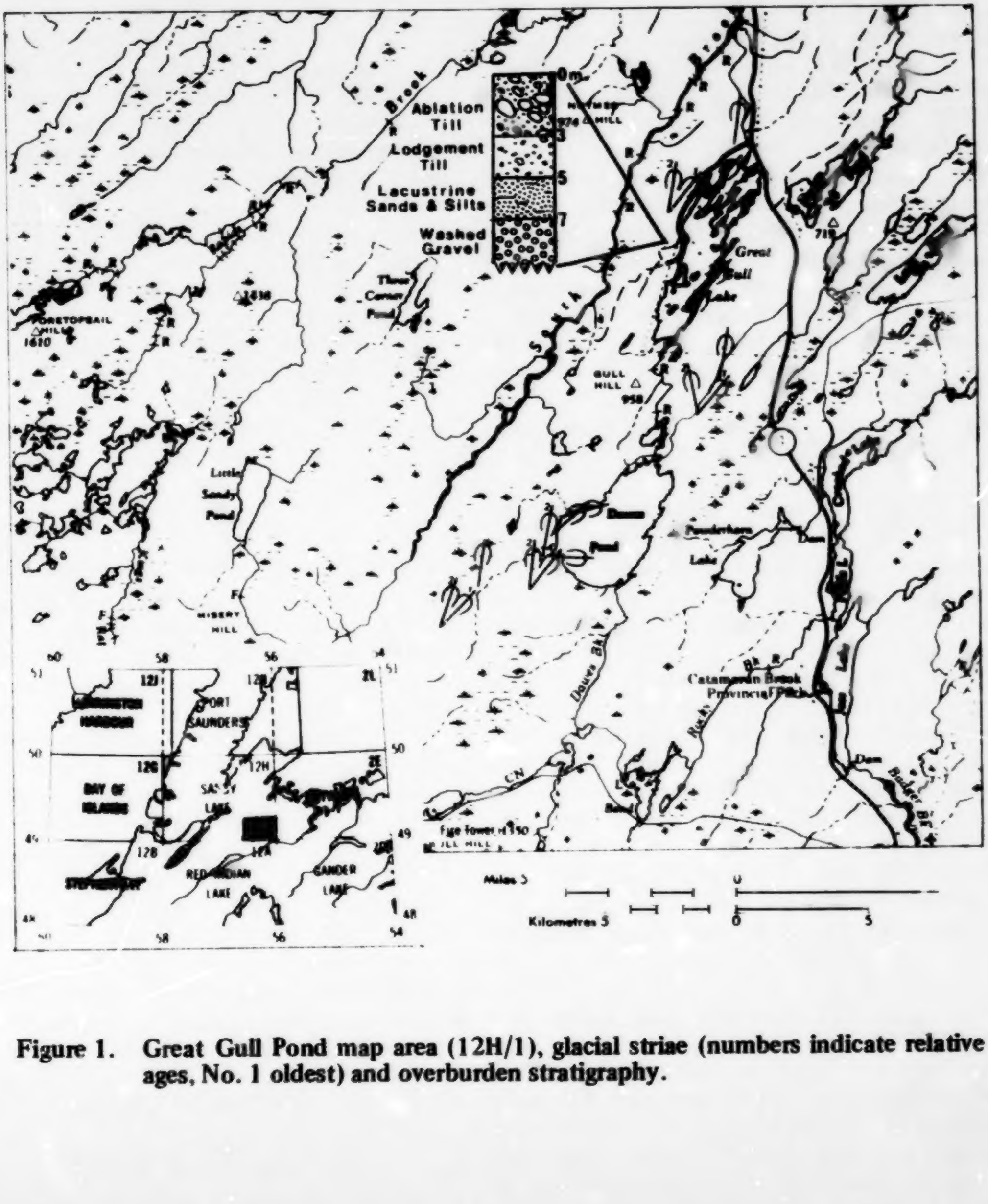

Figure 1. Great Gull Pond map area (12H/1), glacial striae (numbers indicate relative ages, No. 1 oldest) and overburden stratigraphy.

these sediments will complicate the interpretation of data from exploration activities in this area, particularly geochemistry, geophysics and boulder tracing.

Detailed mapping of the Great Gull Pond map area is proposed for 1983 as a continuation of the mapping conducted by Sparkes in 1982 (this volume).

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SURFICIAL AND GLACIAL MAPPING OF THE BUCHANS MAP AREA (12A/15), NEWFOUNDLAND

by

B.G. Sparkes

INTRODUCTION

Mapping was conducted in the Buchans map area during 1982 as a continuation of the Surficial and Glacial Mapping Program in central Newfoundland (Sparkes, 1982). The aim of the project is to provide information on the nature and distribution of surficial landforms and the glacial dispersal of rock materials as an aid to mineral exploration. The Buchans map area has limited road access, relatively few glacial till exposures, and only scattered unweathered bedrock exposures exhibiting glacial flow indicators.

FIELD PROGRAM

Mapping was started late in June and continued until September. Information was obtained along existing roads, lake shorelines, and streams as well as from hand-dug or backhoe-dug pits. Forty-three till fabrics were obtained, 200 sites were noted, and approximately 300 samples of the till were collected for particle size analyses and geochemistry. A representative pebble (+8 mm to -16 mm) fraction was obtained at each site to determine the lithologic composition of the sampled till(s). The lithologic study also included silt/clay coating, weathering, staining, sphericity, fracturing, mineralogy and texture for each lithology present. Additional information was obtained from the 330 overburden drill logs made available from Asarco drill records at Buchans.

PHYSIOGRAPHY

The terrain in the north-central part of the area is characterized by bog underlain by thin till or rock. This part of the area also has many elongate till ridges (*i.e.* drumlinoid). In the northwestern part of the area, where the relief is much higher, there is considerably less bog cover, and a thicker cover of till. Abundant glacial meltwater channels and several large moraines are also located there. The area southwest of Buchans is characterized by moderate to low relief, scattered bogs and many isolated till hummocks. In the shoreline areas of Red Indian Lake, the till cover is more extensive and generally thicker than in the area of the till hummocks.

GLACIAL FLOW FEATURES

Due to an extensive overburden mantle, few striae were observed within the map area (Figure 1). Striae in the Millertown area (southeast corner of map) record an ice flow to the northeast (030) approximately parallel to Red Indian Lake. In the area of the town of Buchans, the striae record a flow to the southeast (160); in the area west of Buchans Lake, flows to the northeast, southeast and west have been recorded. On the shoreline of Red Indian Lake, south of Buchans, striae record a flow to the south and a possibly later flow to the southwest (220-250).

Geomorphic features, such as crag and tail hills and drumlinoid forms north of Red Indian Lake, in the eastern part of the map area, are indicative of ice flow to the northeast. Elsewhere in the map area, there are few apparent geomorphic landform features (other than striae) to indicate the latest direction of glacial transport.

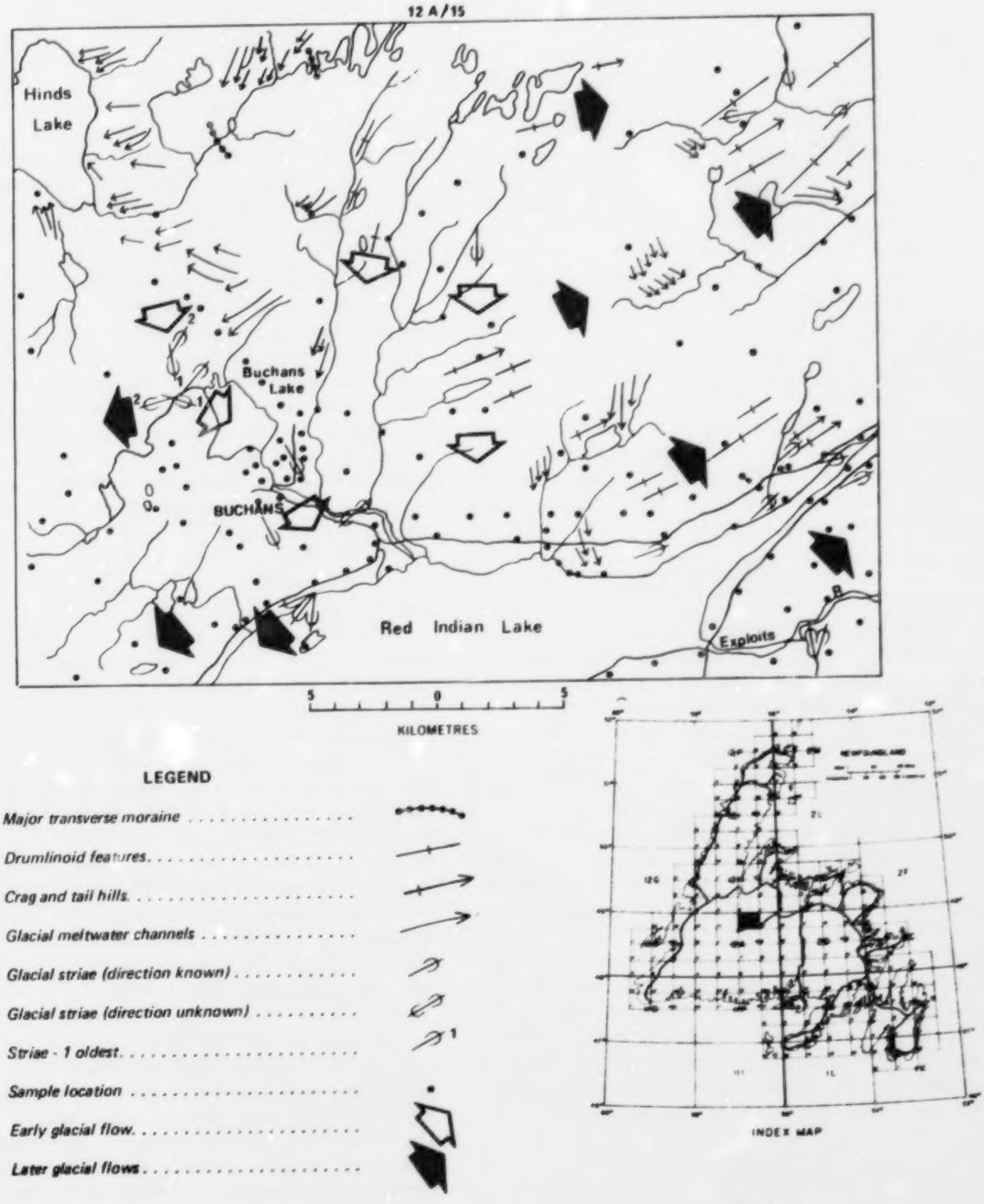
12 A/15
Hinds Lake
Buchans Lake
BUCHANS
Red Indian Lake
Exploits
5 0 5
KILOMETRES
LEGEND
Major transverse moraine
Drumlinoid features
Crag and tail hills
Glacial meltwater channels
Glacial striae (direction known)
Glacial striae (direction unknown)
Striae - 1 oldest
Sample location
Early glacial flow
Later glacial flows
INDEX MAP

FIG. 1

STRATIGRAPHY AND TILL FABRICS

There are two distinct tills within the map area. The stratigraphically lowest till observed is gray, with a silty matrix and usually lacking in fissility; it is commonly of local provenance. The fabrics in this lower unit are inconclusive. This unit is everywhere overlain (where observed) by a red till which generally has a more sandy matrix and contains clasts of more distant provenance. The measured till fabrics in the latter are extremely varied, possibly because of post-depositional reorientation of the clasts resulting in a fabric parallel to the slope at the site.

In the open pit of the Oriental Mine, the gray till contains ore float and sits atop mineralized bedrock. The overlying red till (mainly granitic) is overlain by a third unit, possibly an ablation till. This upper till unit is thin (1-2 m), distinctively lacking in fines or striated stones, and generally composed of clasts of distal provenance (*i.e.* granitic clasts). At the eastern edge of the pit, this upper unit is separated from the red till by a thin wedge of sand which is very compact and oxidized.

At the sandfill pit northeast of Buchans for the Asarco mining operation, 1-2 m of moderately compact, stony till overlies up to 50 m of sand (Asarco drill records). This till is similar to the red till unit in the Oriental pit and is composed mostly of granitic clasts probably derived from sources in the north and northwest.

GLACIAL INTERPRETATION

The Buchans map area was affected by three distinct pulses of ice movement. A flow to the southeast was possibly the earliest event; it probably emplaced the gray till unit. This was followed by ice flows to the northeast and southwest, possibly after or during a period of glacial retreat. These two flows may not have been contemporaneous, as indicated by the presence of considerable sand beneath the red till unit, and may indicate different source areas. The distribution patterns of 'Buchans type' ore float and the orientation of geochemical dispersion trains from Buchans (James and Perkins, 1981) appear to confirm the three directions of ice movement. We hope that the textural, geochemical and lithological analysis of the till samples from the area will provide better understanding of the glacial events.

ACKNOWLEDGEMENTS

The author thanks Jeff Steiner and Paul Skeard for their diligent work, cooperation, and companionship during the field season. Special thanks are extended to Jeff Thurlow, Abitibi-Price, for the provision of Ascarco drill records and valuable discussions while in the area.

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DETAILED AGGREGATE ASSESSMENT PROJECT - INSULAR NEWFOUNDLAND

by

F.T. Kirby

INTRODUCTION

This year marked the beginning of the first detailed aggregate resource assessment project in Newfoundland and Labrador. In previous years, some detailed work was carried out in selected areas (*viz.*, Butts Pond, Sandy Brook - Grand Falls, Gros Morne National Park) and a start was made on the St. John's Urban Region Plan area. The studies were initiated under the Inventory of Aggregate Resources program.

OBJECTIVES OF PROGRAM

The main aim of the project is to identify areas of quality aggregate resources within municipal or other planning areas (*e.g.* agricultural) where the implementation of land use zoning might sterilize (remove from future production) areas of aggregate resources. The process involves locating and sampling in detail any aggregate reserves located within the proposed development areas. In areas lacking quality grade aggregates (*i.e.* gravels and sands), alternative sources such as silt/clay-free till and/or suitable bedrock are assessed in regards to current and future local needs. The designation of the aggregate resources as extraction areas within specific planning proposals (*i.e.* municipal plans) shall ensure that the aggregates can be preserved to meet present and future aggregate demand in the area. This likewise ensures the local domestic and commercial aggregate consumer has access to material at a reasonable cost. After the aggregate resource reserves are depleted, quarry areas are to be rehabilitated to a state suitable for other proposed uses and the area removed from the extractive designation.

FIELD PROGRAM

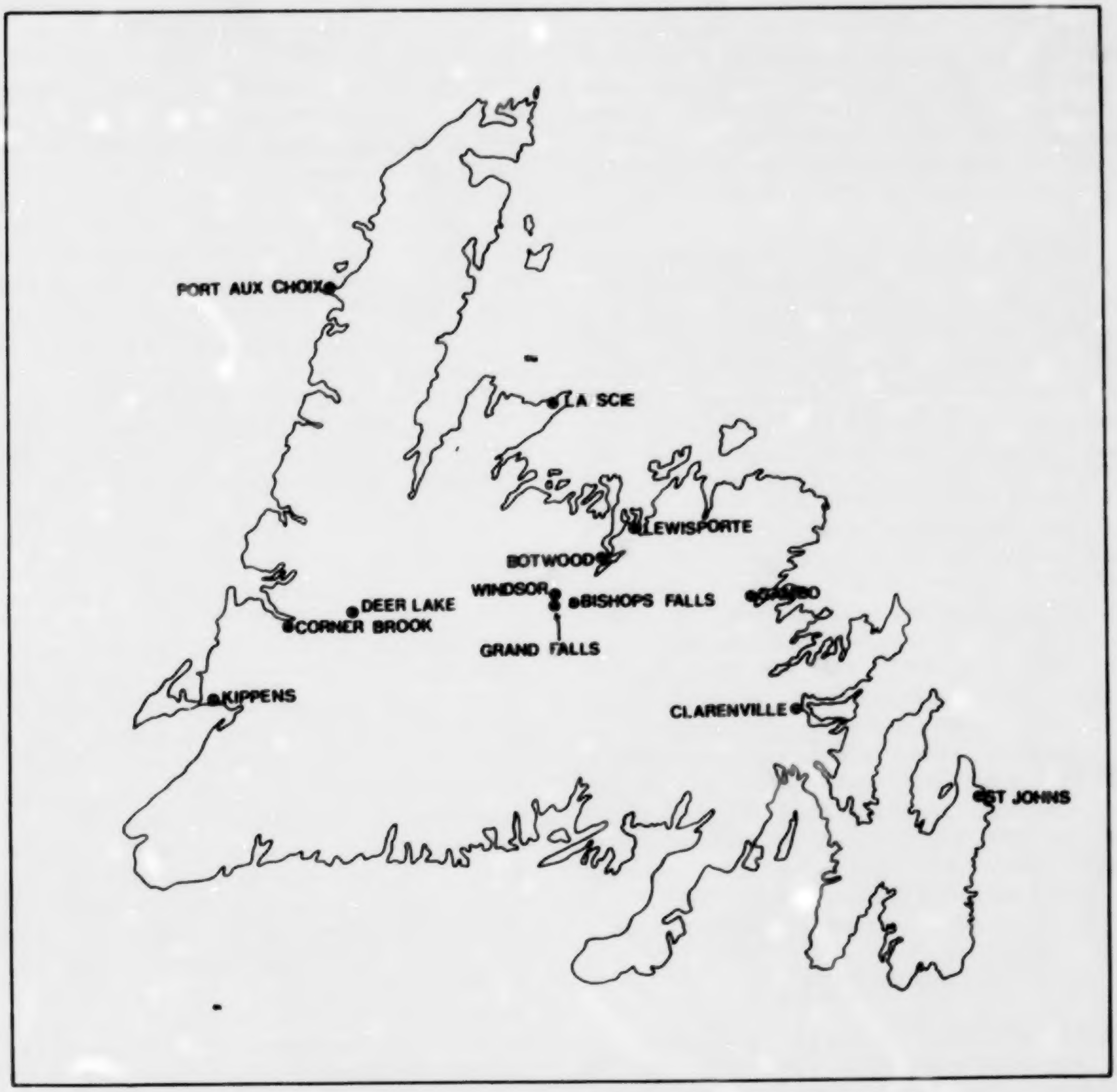
Field work was concentrated in a number of municipal planning areas currently under either review or development; some preliminary work was conducted in the Wooddale agricultural development area and the Deer Lake agricultural area. Municipal planning areas covered were Kippens, Corner Brook, Deer Lake, Port aux Choix, La Scie, Botwood, Grand Falls/Windsor, Bishop's Falls, Lewisporte, Appleton, Gambo and Clarenville. Field work started last year in the St. John's urban area will be completed this fall.

The field work involved extensive use of backhoe (117 hours) to delineate more accurately and to sample the aggregates previously located by field traverses and air photo interpretation under the Reconnaissance Aggregate Resources Program (Kirby *et al.*, 1982). A total of 350 samples were collected in 1982 for particle size analysis and lithological investigation.

Mapping was normally conducted at a scale of 1:12,500 on an orthophoto base, but in areas such as the west coast, where these maps are unavailable, mapping was done on larger scale municipal plans supplied by the Newfoundland Department of Municipal Affairs.

OFFICE PROGRAM

During the winter of 1982-83, maps and sample analyses with accompanying reports will be compiled. They will be forwarded to the Department of Municipal Affairs for inclusion in the proposed municipal plans and to the respective town councils for comment and/or for final approval. In this regard, the town



DETAILED AGGREGATE RESOURCES PROJECT INSULAR NEWFOUNDLAND

FIELD AREAS 1982

council of Kippens recently accepted a plan that recognized the existing aggregate resource areas and a gypsum deposit, and shall protect these from conflicting land use developments.

EUTURE PLANS

Sampling within all municipal planning areas will continue until all areas have been covered. Any proposed agricultural, forestry or other major development that occurs in areas of aggregate resources will be assessed as required.

There are about 310 municipalities in Newfoundland and Labrador. Approximately 50 of these have municipal plans (many of which are due for review) and the Department of Municipal Affairs would like to have municipal plans completed for many of the remaining 260 areas. Funding for this current project is provincial. In 1983 a survey (Detailed Aggregate Assessments - Coastal Labrador) will be conducted in selected coastal communities of Labrador. Funding for the latter project will be cost-shared 50/50 under the Canada/Newfoundland Coastal Labrador Agreement.

ACKNOWLEDGEMENTS

The author thanks Tod Martin and Ray Styles for their assistance in the field and Christine Spurrell for her work in the laboratory.

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INVENTORY OF AGGREGATE RESOURCES PROGRAM

by

M.G. Ricketts and D. Bragg

INTRODUCTION

The Inventory of Aggregate Resources Program (Kirby *et al.*, 1982) was designed as a reconnaissance level program. The project began in 1975, and to date sampling has been completed within a 6 km wide corridor study area. Information on the aggregate resources is now available along all existing and proposed transportation routes in Newfoundland and Labrador within this corridor (Maps 1 and 2).

The 1982 program was mainly office oriented, centered around the compilation of maps and sample data and the development of a computer package designed for search and retrieval of aggregrate resource data.

OFFICE PROGRAM

Most of the work carried out in 1982 dealt with the compilation of two 1:250,000 scale map series each consisting of 30 maps. A colored map series outlines the areas of aggregate potential plus sample localities, sample types and sample numbers. These maps summarize the zones of aggregate potential depicted on the 1:50,000 scale maps. The colored map series, plus report, is hoped to be released before March, 1983. Another series of 1:250,000 scale maps, the geology series, gives a summary of the bedrock geology with emphasis on the geotechnical aspects of bedrock and will include marginal notes on each map with a unified legend. Draft versions of these maps are ready for final cartography. Work on legends and marginal notes should be completed in 1983.

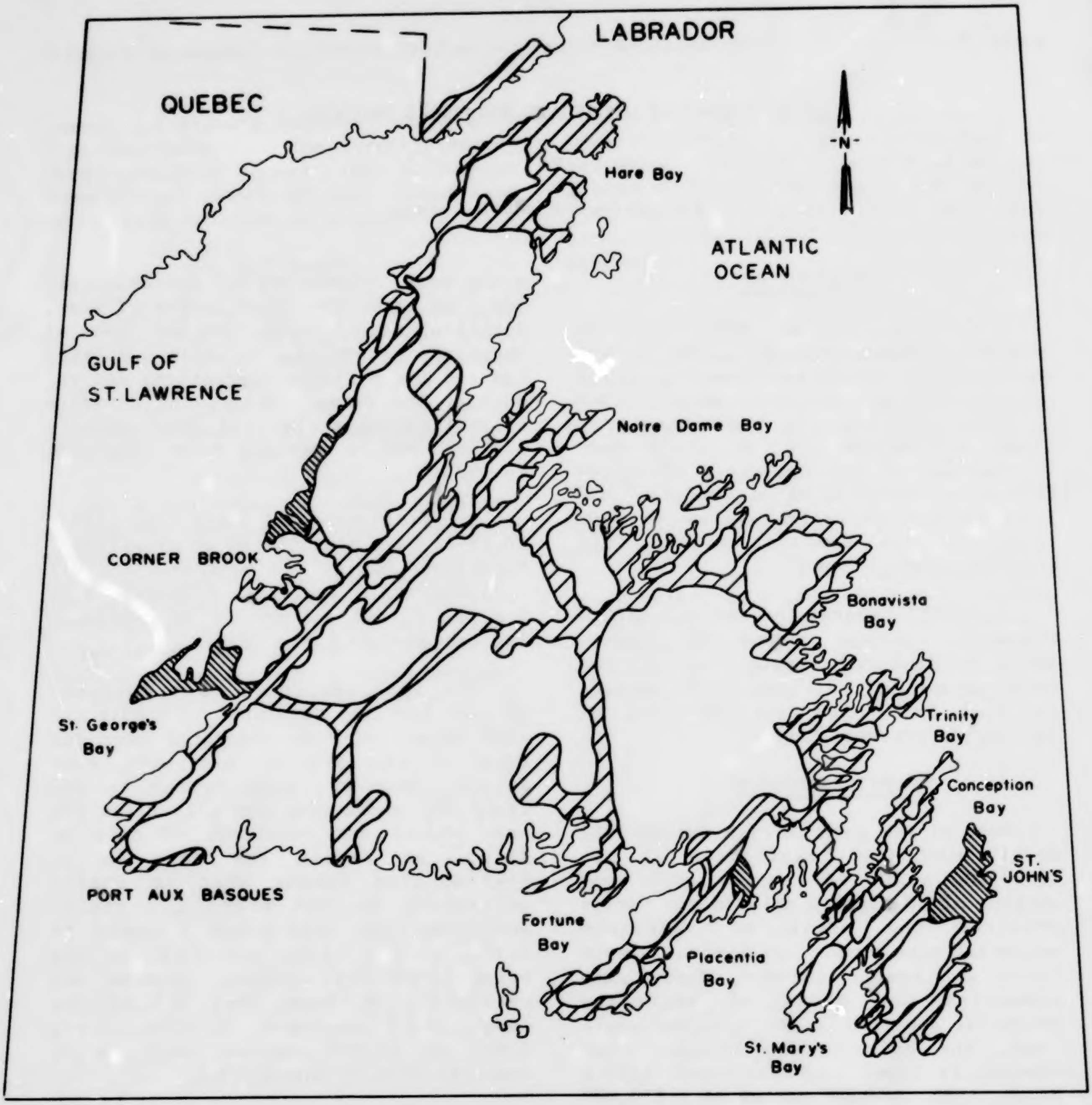
Work is also being carried out on the production of two sets of 1:50,000 scale maps, consisting of approximately 180 maps each. The first series of maps, depicting sample localities and zones of aggregate potential, has been completed (except for periodic corrections and updates). The second series, the landform classification series, is approximately 75% done and is expected to be completed in 1983.

All field maps and field data (prior to 1982) have been placed on microfiche. Microfiche copies are available for all 1:50,000 scale aggregate resources maps for the island and should be available for Labrador in early 1983.

The implementation of a computer package that was developed to handle the vast amount of data generated over the term of the project met with some delays. However, this system is now ready for production and will allow the easy search and retrieval of data on file, and report the data in an English-like format that is easily understood by the user. A computer programmer has been hired recently to assist in this task and data are now being keyed for editing, storage and retrieval. We hope that 50% of the sample data generated to date (*i.e.*, 5,000 of 10,000 samples) will be on computer file by March, 1983.

FUTURE PLANS

The 1983 program will be mainly office oriented, with emphasis on the completion of the surficial (landform classification) maps as well as corrections and updates on the computer data base. It is also planned to complete and update microfiche on all aggregate resources maps and to have all coded field forms transferred onto microfiche for storage.



MAP 1

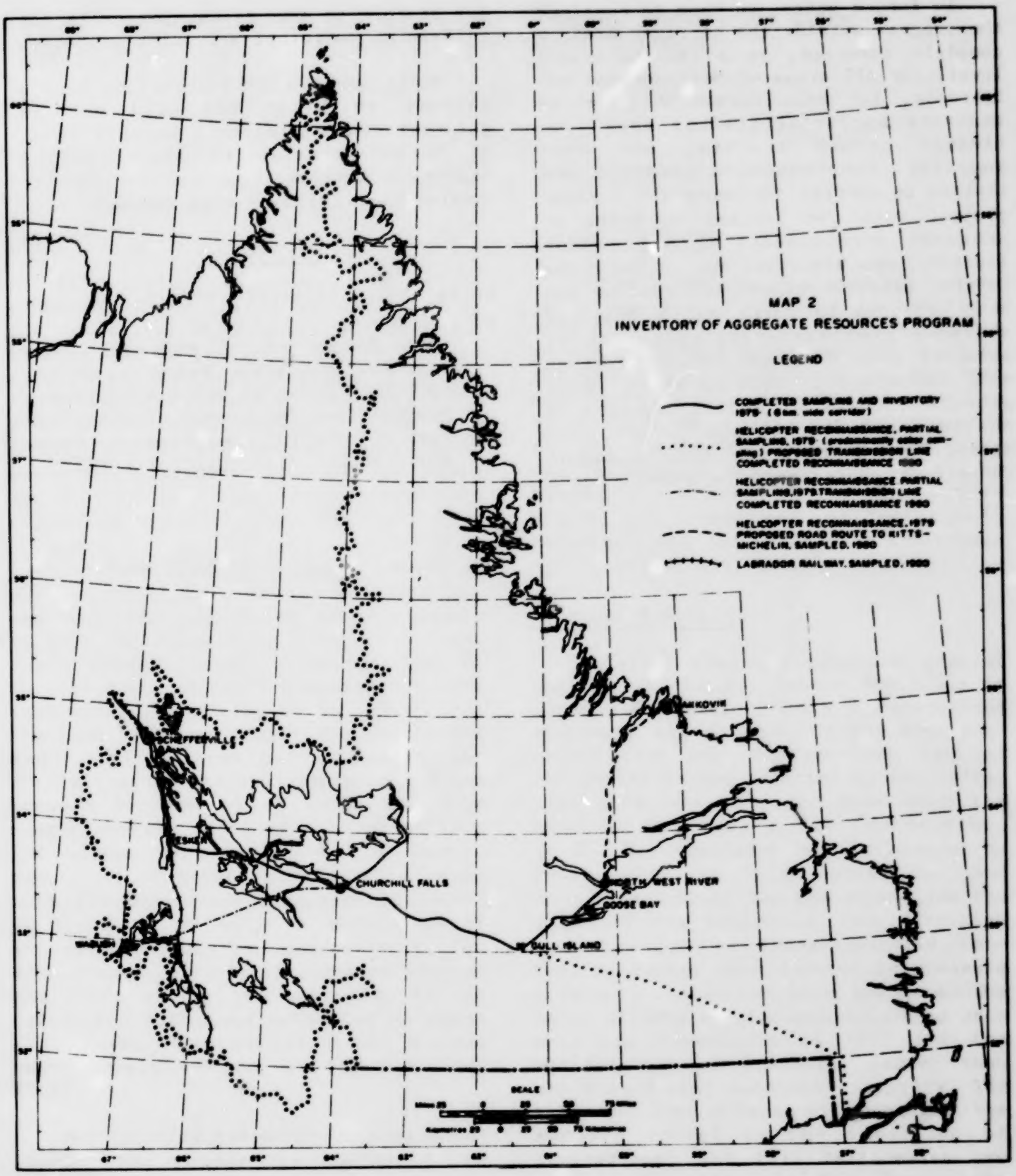
Inventory of Aggregate Resources Program
Island of Newfoundland
CANADA/NEWFOUNDLAND MINERAL DEVELOPMENT SUBSIDIARY AGREEMENT
SUBPROJECT 2.2

Legend

▨ **Completed 6 km wide corridor sampling parallel to existing roads and highways, and selected development areas.**

▩ **1981 fieldwork including detailed assessments in previously sampled areas.**

☐ **Unsurveyed areas, including Terra Nova National Park.**



MAP 2
INVENTORY OF AGGREGATE RESOURCES PROGRAM

LEGEND
COMPLETED SAMPLING AND INVENTORY 1979 (8 km. wide corridor)
HELICOPTER RECONNAISSANCE, PARTIAL SAMPLING, 1979 (predominantly esker sampling) PROPOSED TRANSMISSION LINE COMPLETED RECONNAISSANCE 1980
HELICOPTER RECONNAISSANCE PARTIAL SAMPLING, 1979 TRANSMISSION LINE COMPLETED RECONNAISSANCE 1980
HELICOPTER RECONNAISSANCE, 1979 PROPOSED ROAD ROUTE TO KITTS-MICHELIN, SAMPLED, 1980
LABRADOR RAILWAY, SAMPLED, 1980
MAKKOVIK
SCHEFFERVILLE
ESKER
CHURCHILL FALLS
NORTH WEST RIVER
GOOSE BAY
WABUSH
GULL ISLAND
SCALE
Miles 25 0 25 50 75 Miles
Kilometres 25 0 25 50 75 Kilometres

In future years, we hope to continue the program outside the corridor area to complete coverage, on a reconnaissance level, for all areas of Newfoundland and Labrador. The main thrust will be to generate surficial geology maps with limited ground truthing and some sampling. Comprehensive sampling and testing as carried out under the current project would be limited to areas of proposed developments (*i.e.*, hydroelectric, new highways, etc.). Under the Coastal Labrador Agreement, funding has been provided to carry out a detailed assessment of aggregate resources of selected coastal areas between Forteau and Cartwright. This project will provide results of aerial photography analyses between December, 1982, and March, 1983, to Municipal Affairs and/or consulting contractors to provide data preparatory to the release of calls for tenders on municipal servicing projects.

Field work in 1983 along the Mary's Harbour to Lodge Bay Road and in selected communities will be at a level of detail similar to the Detailed Aggregate Assessment Project - Insular Newfoundland (Kirby - this volume).

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SURFICIAL AND GLACIAL GEOLOGY OF THE WATERFORD RIVER BASIN, ST. JOHN'S, NEWFOUNDLAND: A SUMMARY

by

M.J. Batterson

Introduction

This project represented the first tentative steps during summer 1982, by the Provincial Departments of Mines and Energy, and Environment, toward the use of detailed surficial geology as an aid to hydrologic studies. The Waterford River Basin Urban Hydrology Study is a joint Federal/Provincial Environment Departments project designed to trace the effects of rapid urban expansion on stream water quantity and quality.

The Waterford River Basin covers an area of 60.75 km^2, and is situated immediately west-southwest of St. John's Harbour. Although more than 60% of the basin remains under a natural cover, this is being actively diminished by the expansion of the city of St. John's and the town of Mount Pearl. The overburden mantle often provides a filter for precipitation, and also introduces a lag between percolation of water into the mantle and the entry of this water into the stream system. Removal of such a mantle often produces "flashy" streams with the consequent increased frequency of flooding, as well as alteration of stream morphology and geochemistry. For such reasons a surficial mapping program was initiated, the results to be correlated with data collected on water flow rates, geochemistry and ground water levels as part of the Hydrology Study.

For detailed hydrological considerations the reader is referred to Batterson (1982). This report represents a summary of the surficial geology aspects of the project, and offers some suggestions of the possible effects on stream hydrology of altering the surficial mantle within the Waterford River Basin.

Bedrock Geology

Three lithological groups of Precambrian age are represented in the field area (Hsu, 1976). Green-gray, red, thin to medium bedded siltstone and shale of the Conception Group occur in the west and north, while interbedded gray to black sandstone, siltstone and shale of the St. John's Group dominate the eastern and central areas of the basin. The higher elevations of the South Side Hills are comprised of relatively resistant red and green-gray sandstones of the Signal Hill Group.

Previous Research

Detailed research into the glacial geology of the St. John's Peninsula is scant and therefore only a generalized statement may be made. It has been suggested that only the northern part of the peninsula was affected by ice radiating from the main ice dome over the head of St. Mary's Bay (Vanderveer, 1975). The remainder was influenced by thin, local ice which spread east and west from a minor ice cap straddling the spine of the peninsula. Ice direction was consequently topographically controlled rather than imposed by pressure gradients within the main ice mass. The major effects of glaciation in this area were the deposition of till and the modification of drainage, rather than any significant erosional activity. The till had the effect of smoothing the surface relief by the infilling of depressions, and till thicknesses are characteristically variable. Due to the thin nature of the ice, deglaciation was probably rapid, a view confirmed by a date of 9270 + 150 years from Sugar Loaf Pond northeast of St. John's (MacPherson, 1982), the oldest date for vegetation regeneration from the Avalon Peninsula.

M.J. Batterson

WATERFORD RIVER BASIN

Methods

Mapping was completed at 1:12,500 scale and followed standard investigative procedures. Detailed profile examination and overburden thickness calculation were carried out across the basin, and included 195 site descriptions and 68 samples. Due to the lack of sections down to bedrock across much of the basin interior, overburden depth data was obtained using a Huntec FS-3 portable hammer seismograph.

Samples from each stratigraphic unit identified were sieved and pipetted (<63 μm fraction), and results were plotted as grain size distribution curves using a Hewlett-Packard desk top computer. Pebble analyses were conducted on the 16 mm retained fraction of field samples.

Results

a) Overburden Thickness

The overburden topography is extremely variable in the Waterford River Basin, ranging from 0-5 m. Numerous rock outcrops occur across the basin but nonetheless an overburden thickness map was prepared, which attempted to illustrate trends rather than to provide specific on-site values (Fig. 1). The map shows that areas of zero overburden are confined to the summits of Kenmount Hill and the South Side Hills, and to the lower reaches of the Waterford River and its major tributary, South Brook. Areas of thicker till (3-5 m) are located in the central and central-southern parts of the basin, with an anomalous area to the northeast of Kenmount Hill, which probably represents a lee-side till element. The remainder of the basin, essentially the moderately sloping areas surrounding basin highs, is characterised by overburden depths of 0-3 m.

b) Overburden Texture

Three till units, beneath the soil horizons, can be identified across the Waterford River Basin, although rarely do they occur in a single stratigraphic section.

Directly overlying the bedrock in all cases, the most ubiquitous deposit can be described as an overconsolidated, slightly fissile, light gray, very poorly sorted lodgement till. The till matrix is poorly developed and exhibits a bimodal grain-size distribution. The unit is dominantly clastic with an average silt-clay content by weight of 10%. Clasts are all of local provenance, and represent transportation distances of less than 2 km.

In the western half of the basin and on the South Side Hills, a pale olive to light yellowish brown, poorly sorted, clast-supported till is present. Any matrix is coarse to medium sand in texture, with very little associated silt and clay (average 3.7% silt plus clay), the silt often concentrated in thin lenses. The deposit is a supraglacial facies formed by a melt-out process.

Over the part of the basin where a supraglacial till is not evident, a compacted, light gray to white, poorly sorted till is exposed, overlying the lodgement till unit. The deposit has a higher (18.1%) silt-clay content than does the underlying till, and a grain-size distribution which is bimodal to polymodal in nature. These characteristics, plus a lack of fabric or structure, and the presence of striated clasts and an often thick (>0.5 mm) silt-clay coating around clasts, lead to the conclusion that this deposit is a subglacial melt-out unit.

c) Ice-Flow Indicators

Features recording the direction of glacial events are relatively rare across the basin. In the west and north of the basin, striae record an ice-flow direction consistent with valley orientation, while to the east poorly developed lineations trend in a northerly to northeasterly direction.

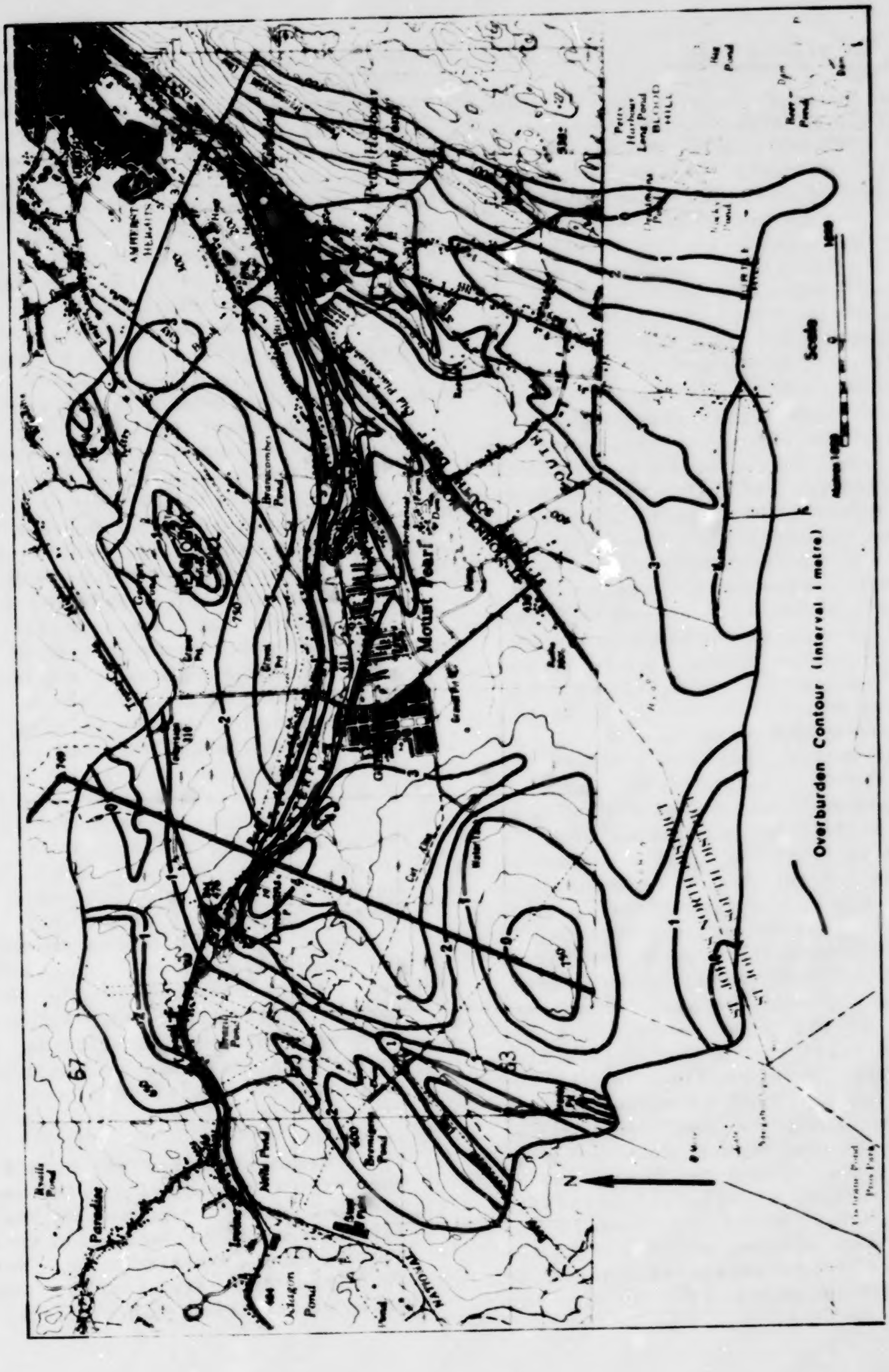

Fig 1. Summary of Overburden Thicknesses in the Waterford River Basin.

Summary of Glacial Events

The contrast in till units across the Waterford River Basin provides an insight into the glacial activity of the area. It is likely that a more active ice-flow occurred over the low-lying areas west of the South Side Hills, which deposited thicker tills and provided lineation of the till surface. This ice originated to the south or southwest of the basin. Similar lineations are not recorded in the west, although thick tills are evident there. Furthermore, the development of terraces along the South Side Hills and Kenmount Hill may be evidence of ice downwasting in this area. Meltwater was concentrated between the ice and the South Side Hills during deglaciation, forming a series of terraces. Similarly, the abundant meltwaters may explain the lack of supraglacial deposits in the area. To the west meltwaters were less abundant, possibly because of the shadowing effect from surrounding hills, and a supraglacial mantle was emplaced upon the underlying units. Ice in the west was probably stagnant while that in the east was still active.

In general, the evidence within the Waterford River Basin conforms with the accepted ideas of the glacial history of this part of the Avalon Peninsula - a thin ice cover, the flow lines of which followed the pre-existing topography in a roughly southwest to northeast direction. Tills are short-distance-transported and poorly developed, and are variable in thickness. However, it has also been noted that a more active flow in the east produced lineation of the till surface followed by meltwater concentration along the South Side Hills, while to the west more stagnant ice conditions prevailed and the deposition of a full suite of glacial deposits occurred. That active ice flow in the east and more stagnant conditions in the west were contemporaneous cannot be stated with certainty.

Hydrological Conclusions

Since this report is designed as an aid to the Waterford River Basin Urban Hydrology Study, it seems appropriate that some conclusions of a hydrological nature drawn from this project should be presented at this time. Two major conclusions may be suggested:

1) Till unit variations across the basin produce hydrological differentation, especially between the highly compacted lodgement till which is enriched in fines compared to the overlying less compacted, coarser supraglacial unit. Percolation into and through the upper layer would be relatively unimpeded compared to the lower lodgement till where pore spaces are small due to the higher silt-clay content and overconsolidation. Similarly, discharge from the lodgement till is also slow, but probably continuous even through long periods of drought. This till contains no fractures through which rapid discharge may be facilitated. During periods of precipitation the upper supraglacial unit is rapidly saturated, developing a perched water table and often producing surface ponding of water. In the remainder of the area where the supraglacial unit is absent, ponding of water will also occur in topographic lows underlain by the subglacial till. Similarly, due to the thinness of the overburden in all cases, bedrock control over water movement is critical. The hydrological response of the drainage basin to precipitation event is therefore rapid.

2) Urban development now and with further expansion will affect the movement of water through the basin. Initial removal of vegetation speeds the surface transmission of water into the drainage system, while urban construction either affects or

> removes the critical supraglacial layer, thereby reducing the overall storage ability of the groundwater environment. The effects are to increase runoff and flooding potential, factors which are compounded in the lower Waterford River Basin due to the narrow, incised nature of the basin at this point. Increased flooding is more likely to occur in this and other areas across the basin in the future.

This rapid discharge of water into the stream system following precipitation events will have the combined effect of increasing incision of the stream channel into the overburden mantle and also increasing sediment content. Similarly, the geochemistry of the stream will change since the filtering effect of the till is removed.

In general the thinness of the overburden and the compaction of the subglacial unit are the major influences affecting groundwater movement throughout the Waterford River Basin.

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CORE STORAGE PROGRAM, 1982

by

A. Harris and S. Cochrane

During 1979, the Newfoundland Department of Mines and Energy started a drill core collection and storage program. The primary objective is to provide well maintained and representative collections of drill core from as many drilling programs as possible for the future use of the mineral exploration industry, government geoscientists, university geoscientists and other geotechnical people.

I. Drill Core Collection

During the 1982 field season, drill core collection from abandoned drill sites was continued in Insular Newfoundland and started in Labrador. In Insular Newfoundland, 55,430 m of core were collected from 21 drilling projects. In addition, the 32,345 m of core at a temporary storage site in Pynn's Brook was moved into the Pasadena core library. Figure 1 shows the location of sites from which core has been collected in Insular Newfoundland and Table 1 provides a list of the collected core.

In Labrador, 8,804 m of drill core were collected from seven sites and moved into the Goose Bay core library. The collection effort in Labrador during 1982 concentrated on the western part of the Central Mineral Belt, NTS area 13K. Figure 2 shows the location of sites from which core has been collected in Labrador and Table 2 provides a summary of the collected core.

New acquisitions of drill core from Labrador and Insular Newfoundland during 1982 total 62,029 m. To date, the core storage program has collected 120,306 m of drill core.

The Department of Mines and Energy is presently storing some drill core on a confidential, temporary basis. Proposed legislation regarding the storage of core classified as confidential is presently being finalized. It is expected that confidentiality of drill core will be tied to land status and will be similar to the terms and conditions of confidentiality which presently apply to assessment reports.

Another measure under consideration to assist our efforts in the acquisition and preservation of drill core is the offering of assessment credits to exploration companies to cover the cost of delivering core to our core libraries.

II. Drill Core Libraries

The Department of Mines and Energy now operates three drill core libraries. These libraries are located in St. John's, Pasadena and Goose Bay (Figure 3).

The St. John's core library is fully operational and is staffed on a full-time basis, except during the field season. It has capacity of 60,000 m of drill core. Approximately 12,000 m of drill core have been cataloged and placed on the rack system to date. Most of this core is from eastern Newfoundland, from the St. Lawrence area and the "silica survey" drilling conducted by the provincial government during the 1960's. Drill hole logs and location maps have been prepared for cataloged core. The St. John's library also contains rock cutting equipment, core splitters, a stereomicroscope, a

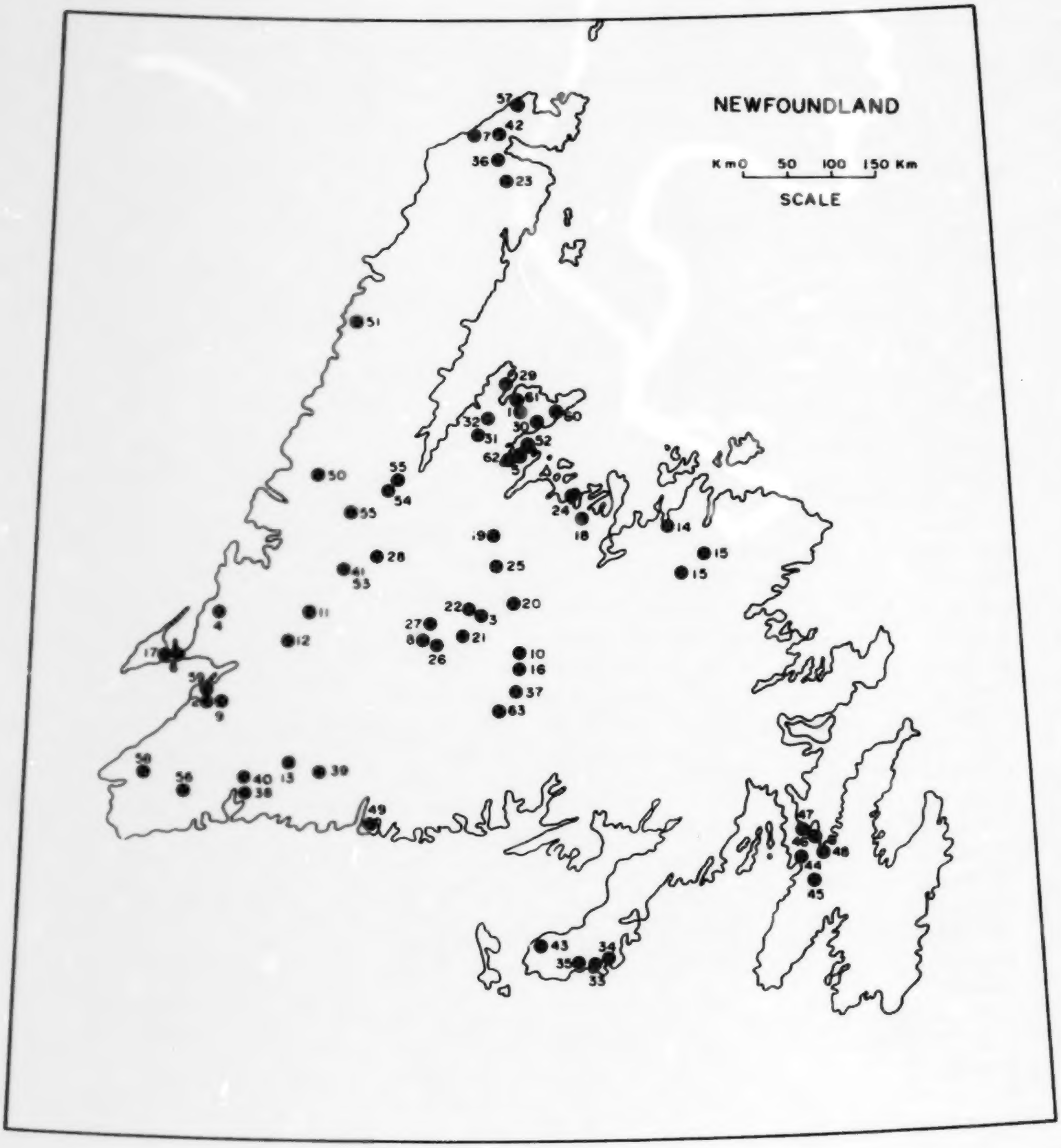

FIGURE I. CORE COLLECTION SITES
INSULAR NEWFOUNDLAND

TABLE 1: SUMMARY OF CORE COLLECTED TO DATE - INSULAR NEWFOUNDLAND

No.	Company	Year	Property	# of Holes	Total Metres	Storage Location
1	Advocate	1967	Rambler	2	1,193.0	TS
2	Amax	1976	Fischells Area	2	1,420.3	P
3	Amoco	1978	Burnt Pond	4	609.6	TS
4	Beth Canada	1978	Springer's Hill	10	911.7	P
5	Bovlen-Cerro		Colchester	18	1,379.2	TS
6	Canadian Ref.	1970	Aguathuna	13	850.1	P
7	Chevron	1979	Eddies Cove	11	481.6	P
8	Cominco-Hansa	1973(?)	Bobby's Pond	5	431.6	TS
9	Hooker Chemical	1968	Fischells	1	173.4	SJ
10	HBOG	1978	Gt. Rattling Bk.	11	818.6	TS
11	HBOG	1978	Reid Lot 223	5	306.3	TS
12	HBOG	1978	Reid Lot 225	2	117.0	TS
13	HBOG	1978	Top Pond	1	47.1	TS
14	Internat. Mogul	1974	Campbellton Area	15	1,394.5	TS
15	Internat. Mogul	1975	Gander Area	12	708.7	TS
16	Minorex	1978	Atlantic Lake	6	439.5	TS
17	Nfld. Mines Br.		Port au Port	?	811.5	P
18	Noranda	1972	Point Leamington	3	265.8	TS
19	Noranda	1973	Gullbridge	1	54.9	TS
20	Noranda	1975	Leonard's Lake	3	388.6	TS
21	Noranda	1975-78	Tally Pond	2	489.2	TS
22	Noranda	1978	Burnt Pond	2	165.0	TS
08	Noranda	1978	Bobby's Pond	4	320.6	TS
23	Shell Can. Res.	1975-76	Main Brook Area	32	1,859.3	P
24	Texas Gulf	1975	Seal Bay	8	1,104.9	P
19	Gullbridge Mines	?	Gullbridge	213	12,473.9	P
25	Consol. Morr.	1976	Lake Bond	2	419.1	P
26	L.M. & E.	?	Lake Ambrose	6	647.7	SJ
27	Kerr Addison	1974-75	Victoria Area	5	655.3	P
28	Shawmont	1977-78	Hinds Brook	28	822.9	P
29	Advocate	?	Priests Showing	8	774.8	P
30	Advocate	?	Nippers Harbour	7	946.1	P
31	Advocate	1976	West Pond	3	144.7	P
32	Advocate	1975	Flatwater Pond	11	907.6	P
33	ALCAN	?	St. Lawrence	?	8,153.4	SJ
34	D.S. Robertson	?	Mt. Margaret Area	?	4,463.8	SJ
35	D.S. Robertson	?	Lawn Area	?		SJ
36	Noranda	?	Round Pond Area	?	?	P
37	RIOCANEX	1976	Cold Spring Pond	1	30.0	SJ
38+	Falconbridge		Strickland Property	?	4,427.2	P
39+	Falconbridge	1981	Burgeo Road	16	1,059.2	P
40	Long Lac Min.	1968	Strickland Property	18	975.3	P
41	Minorex	1978-80	Deer Lake	25	1,993.3	P
42	U.S. Borax	1979	Hidden Pond	11	237.6	P
43*	Nfld. Mines Branch	1960's	Fortune (Silica)	3	199.9	SJ
44*	Nfld. Mines Branch	1960's	Long Harbour (Silica)	6	232.5	SJ

TABLE 1 (Cont'd)

45*	Nfld. Mines Branch	1960's	Argentia (Silica)	11	731.6	SJ
46*	Nfld. Mines Branch	1960's	Thornlea (Silica)	6	230.9	SJ
47*	Nfld. Mines Branch	1960's	Bellevue (Silica)	7	187.1	SJ
48*	Nfld. Mines Branch	1960's	Long Cove (Silica)	4	164.1	SJ
49*	Nfld. Mines Branch	1960's	Grey River (Silica)	6	256.2	SJ
50*	Nfld. Mines Branch	1960's	Bonne Bay (Silica)	4	197.2	SJ
51*	U.S. Borax	1981	Daniels Harbour	2	804.6	P
52*	Minorex	1981	Silverdale	7	203.6	P
53*	Minorex	1979-80	Deer lake	?	109.7	P
54*+	Westfield Minerals	1978-81	Deer Lake	130	8,314.9	P
55*+	Northgate Expl.	1979	Deer Lake	16	2,511.5	P
56*+	Riocanex	1978-81	Cape Ray	?	13,637.0	P
57*+	Essex	1981	Watts Bight	4	609.6	P
58*+	Shell Can. Res.	1980	Codroy Valley	6	890.0	P
59*+	Flintkote	1979-80	Flat Bay	?	3,214.0	P
60*+	Newmont	1981	Tilt Cove	6	864.1	P
61*+	Rambler Mines	?	Ming Mine	60	17,153.0	P
62*	BRINEX	?	Whalesback	54	3,456.0	P
63*+	Riocanex	1976	Great Burnt Lake	9	1,463.0	P
				Total	111,304.4 m	

Key -
P - Pasadena Core Library
SJ - St. John's Core Library
TS - Temporary Storage Springdale
* - Collected 1982
+ - Temporary Confidential Storage

TABLE 2: SUMMARY OF CORE COLLECTED TO DATE - LABRADOR

No.	Company	Year	Property	# of Holes	Total Metres	Storage Location
1*	American Metal Co.	1954	Green Pond	3	16.7	GB
2*	Brinex	1972	Seal Lake	19	1,333.5	GB
3*+	Canadian Nickel Co.	1978-80	Moran Lake	30	2,103.1	GB
4*	Mokta Can. Ltd.	1965	Moran Lake	8	220.9	GB
5*	Northgate Explor. Ltd.	1980	Lake Melville	8	652.2	GB
6*+	Placer Devel. Ltd.	1980-81	Banana Lake	11	655.3	GB
7*	Riocanex	1961	Ten Mile Lake	4	197.5	P
8*+	Shell Can. Res.	1977-79	Moran Lake	61	3,822.2	GB
				Total	9,001.4 m	

Key -
GB - Goose Bay Library
P - Pasadena Library
* - Collected 1982
+ - Temporary Confidential Storage

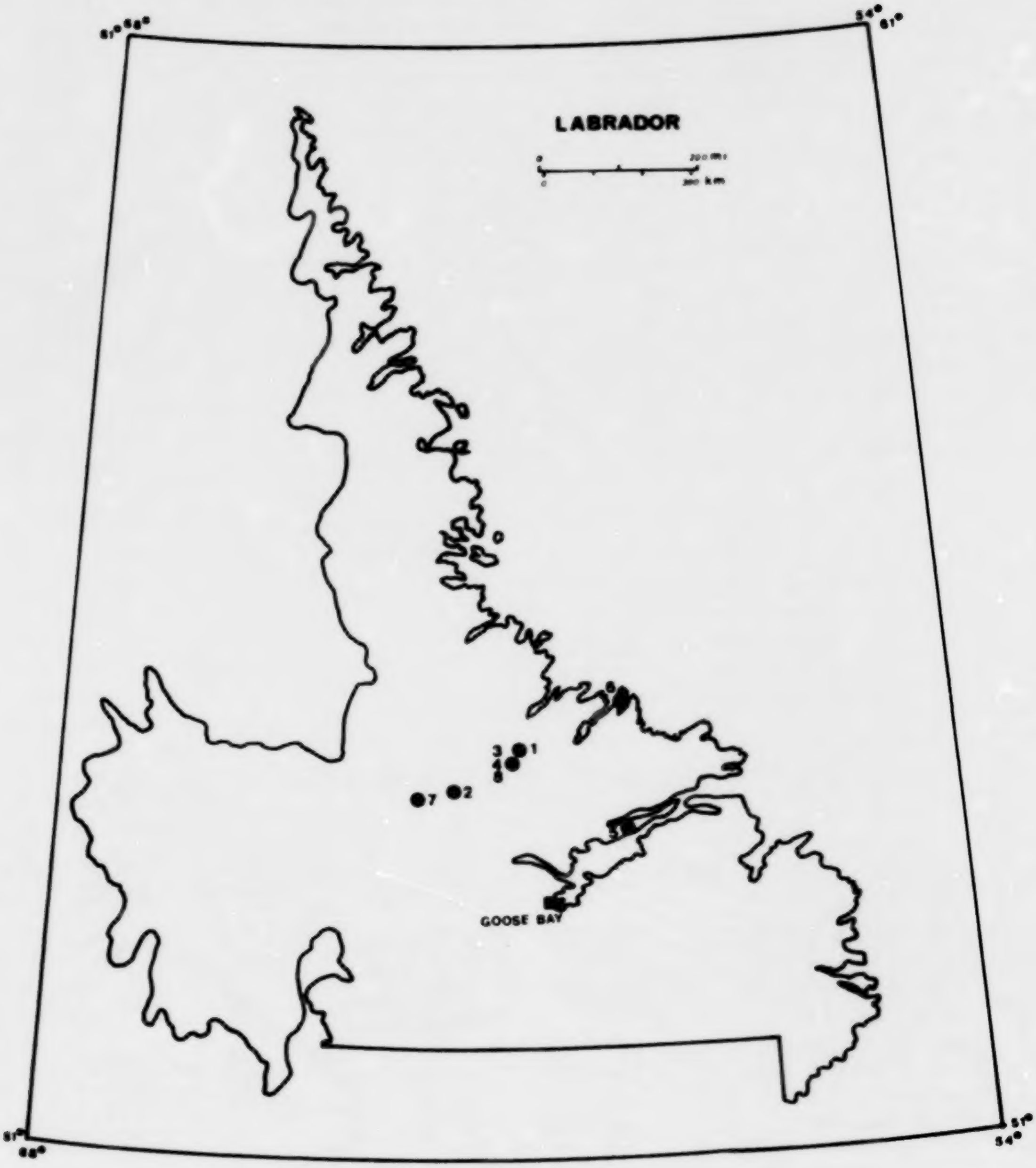

FIGURE 2. CORE COLLECTION SITES LABRADOR

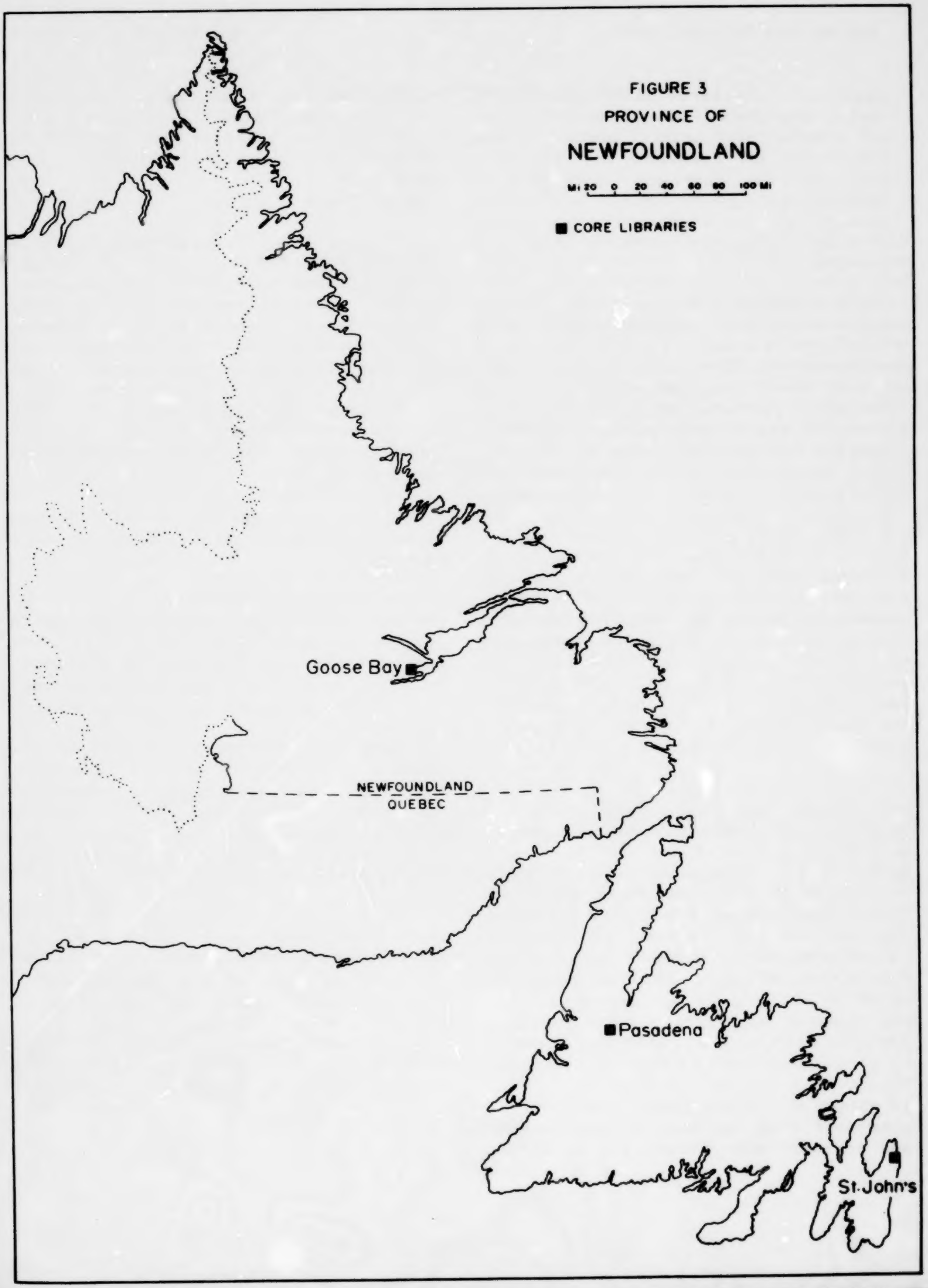

FIGURE 3
PROVINCE OF
NEWFOUNDLAND

magnetic susceptibility meter, a resistivity meter, an ultraviolet light and a McPhar TV-1 scintillometer. These facilities and equipment are available for use on approved projects by exploration geologists, university researchers, the staff of the Department of Mines and Energy and other interested persons.

The Pasadena core library is also fully operational and is staffed on a full-time basis. This library has equipment and facilities similar to the St. John's library and has a capacity of 200,000 m of core. It has a ventilated room for storing radioactive core and a humidity-controlled room for storing salt core. There are approximately 85,000 m of core presently stored in the Pasadena library, collected from drilling sites west of Gander.

The Goose Bay core library has been recently completed but is not yet fully operational and is not staffed on a full-time basis. It has a capacity of 60,000 m of core with space available for future expansion. This library also contains equipment and facilities similar to the St. John's library.

Future Plans

Future plans include cataloging and indexing all the core collected to date and continuing collection programs, with emphasis on St. John's and Pasadena during the offseasons. The cataloging and indexing of core in the Goose Bay library is scheduled for July 1983 and the field collection program in Labrador will continue during the 1983 field season. We encourage operators to bring your drill core to our nearest facility at any time.

A computerized drill hole index has been developed and will continue to grow as indexing of core progresses.

A published drill hole index in map or booklet form is tentatively scheduled for late 1983.

GEOFILES - MICROFICHE PROJECT

by

N.L. Mercer and R. Soper

The Mineral Development Division maintains a geological and mineral resource assessment file system commonly referred to as the "geofiles." The geofiles presently consist of approximately 8,500 geological reports, maps, journal articles, and mineral assessment files, making them the largest and most comprehensive single collection of geoscience documents about Newfoundland and Labrador.

With the high level of mineral exploration activity experienced over the last few years throughout the province, the amount of new data submitted has increased substantially. This trend is expected to continue as more land comes open for claim staking, and as new geological and geochemical reports and maps are published by the Department on the mineral potential of various regions of the province.

Mining and exploration companies, geotechnical and consultant firms, government agencies, universities, libraries and the general public are continually making use of the geofiles and requesting information from them. Requests have tripled in the past few years.

During the past three years, the Publications and Information Section has been putting all of the geofiles on microfiche. This will provide a much more efficient system of maintaining the geofiles. Requests for information will be handled more easily, with relatively inexpensive charges for microfiche duplicates.

The project has involved daily filming of batches of files. The files are cross-checked before filming for quality, content and reproducibility. Two fiche originals are made and cataloged for each file. Filing follows the standard NTS system presently used in the Department. Duplicates can be copied from the original fiche upon demand. One set of fiche originals is stored offsite at the Torbay Core Library for security and protection from fire.

Presently, over 90% of the microfiching has been completed on the project. The remaining work consists essentially of cross-checking for old and missing files and having old reports retyped and poor quality maps redrafted. Attempts will be made to obtain old company data from various mining company offices. Also, each month, new assessment files and publications are microfiched to keep the geofiles up to date.

Over the past two years the Department has been providing microfiche copies of new open files and reports as they become available. Also, many requests from mining companies for geofile data have been filled with microfiche. During 1982, several new microfiche viewers were purchased, including several portable models for use by geologists in the field. These complement the microfiche viewers and reader printers (16 mm and 35 mm) available for office use.

This past year, microfiche copies of nonconfidential geofiles have been made available for several new areas on the

Island. The releases pertain to those open geofiles that have produced top quality film. There will be future updates to the initial releases as other files are upgraded to produce good quality microfiche.

As of early October, 1982, microfiche sets of geofiles covering all 1:250,000 NTS blocks in insular Newfoundland are available at a total cost of $1,122. We expect to complete the Newfoundland General series of geofiles by the spring of 1983, at least for initial releases.

For more information on the microfiche project, please contact Norman Mercer (709) 737-3159. We look forward to your comments and suggestions.

ACKNOWLEDGEMENTS

The Department of Mines and Energy acknowledges the continued participation and cooperation of Ches Hapgood and staff of the Micrographic Section, Newfoundland Department of Public Works and Services, on the microfiche project, especially in filming and duplicating the geofiles.

GEOSCAN - THE NATIONAL DATABASE FOR GEOLOGICAL INFORMATION: 'THE NEWFOUNDLAND CONTRIBUTION'

by

C. Patey

GEOSCAN is a computerized bibliographic database of Canadian-produced and/or Canada-related geoscience documents.

The Newfoundland Department of Mines and Energy is one of the ten agencies which produce indexed documents. The 'geofiles' and the mineral inventory cards at the Publications and Information Section are the sources of our indexed documents. Other agencies, *e.g.* the Geological Survey of Canada and the Earth Physics Branch of EMR, also produce and index documents that concern this province.

As of June 1982, there were approximately 7000 documents that concerned this province in the GEOSCAN database. They include assessment files, serial literature, government reports and maps, theses, and consultant reports.

Usually, once per year, we arrange with the National GEOSCAN Centre to produce some custom indexes from the database. The most popular have been the NEWFOUNDLAND/LABRADOR NTS INDEX and the NEWFOUNDLAND/LABRADOR KEYWORD INDEX.

SALE AND USE OF GEOSCAN INDEXES (FEBRUARY 1981 UPDATE)

TYPE OF AGENCY	NTS INDEXES paper	 microfiche	KEYWORD INDEXES microfiche only
Mining companies	12	23	26
Consultants	3	1	1
Universities/Libraries	0	1	1
Governments	2	2	2

This summer, 1982, we received NEW indexes, current to February 1982. These are now available from the Publication and Information Section (see page 23 of the publications list). As well as the regular KEYWORD and NTS Indexes, there are new indexes offered:

- a less bulky, paper copy, NTS index in reduced format,
- an author index on microfiche only,
- a drill hole, drill hole section and drill hole log index on microfiche only.

The indexes are for the benefit of you, the user. We welcome suggestions for improvements and appreciate being notified of any errors or discrepancies that you may discover.

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The above products and services are the last that will be offered in the old format. The National GEOSCAN Centre, which manages GEOSCAN, is presently implementing a new software system, called MINISIS, to input and retrieve the bibliographic data more effectively. For at least a year, the old and the new systems will be operating concurrently. All new documents are input on the new system and are immediately retrievable. The old documents are available in the above indexes and old on-line service, but cannot be updated (corrected, deleted, status changed, etc.) until after all the documents on the system are converted to the MINISIS system. When the new system is fully in place, GEOSCAN should be a much more valuable tool in our search for new mineral resources.

For further information on GEOSCAN, please contact Catherine Patey (709) 737-3159. We look forward to your comments and suggestions.

GRANITOID CLASTS IN BOULDER BRECCIAS OF MACLEAN EXTENSION OREBODY, BUCHANS, NEWFOUNDLAND[1]

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Stewart, P.W., Granitoid clasts in boulder breccias of MacLean Extension orebody. Buchans, Newfoundland; in Current Research, Newfoundland Department of Mines and Energy, Mineral Development Division, Report 83-1, p. 215-218, 1983.

Also in Current Research, Part A. Geological Survey of Canada, Paper 83-1A, p. 321-324, 1983.

Abstract

Approximately fifty per cent of the Buchans massive sulphide orebodies mined to date occurred in subaqueous breccia-conglomerate beds within an Ordovician-Silurian volcanic island-arc sequence, the Buchans Group. Amongst the diverse lithic clasts in these beds are rounded, subspherical granitoid pebbles, cobbles and boulders. An intrusive body to the southwest of the mine area, the Feeder Granodiorite, is lithologically similar to some of the granitoid clasts and has been interpreted to be comagmatic with some of the Buchans Group volcanic rocks. Twelve types of granitoid clasts were recognized based on megascopic characteristics but this number will probably be reduced after laboratory investigations have been completed.

Introduction

The volcanogenic sulphide ore deposits at Buchans occur as three types: stockwork ore, in situ ore and transported ore (Thurlow, 1981a; Thurlow and Swanson, 1981). The transported ore forms a series of sulphide-bearing breccia-conglomerate beds with diverse lithic clasts, including granitoids (i.e. plutonic rocks of felsic to intermediate composition) within an Ordovician-Silurian sequence of subaqueous volcanic, volcaniclastic and sedimentary rocks. The source of these granitoid clasts has been enigmatic. An intrusive body of small surface area (approximately 1.5 km^2), the Feeder Granodiorite, outcrops 12 km southwest of Buchans. It has been interpreted to be comagmatic with Buchans Group volcanics and the possible source of the granitoid clasts (Thurlow, 1981b). A description of the central volcanic belt is given in Kean et al. (1981).

It is the intent of this study to determine the petrological character, geochemistry, and age of the granitoid clasts and of the Feeder Granodiorite and shed light on the relationship of the Feeder Granodiorite to the Buchans Group and the included granitoid clasts, and in turn on the provenance and derivation of the clasts.

Acknowledgments

The author is grateful for co-operation and help at Buchans from J.G. Thurlow, E.A. Swanson, W.P. Binney and the staff of ASARCO and Abitibi-Price.

D.F. Strong, W.H. Poole and R.V. Kirkham made many useful suggestions to improve the manuscript.

Underground Observations

The transported orebodies consist of a sequence of breccias and conglomerates which are considered to show characteristics of sediment gravity flow deposits (Walker and Barbour, 1981; Binney et al., 1983). Detailed examination of those units which are relatively rich in granitoid clasts indicates that most granitoid-rich units overlie and flank the sulphide-rich breccias. Granitoid clasts, however, are found in other units not intimately associated with the sulphide-rich breccias. These granitoid clasts are typically smaller (pebble-sized) than the typical cobble-sized granitoid clasts found with the ore. Rare granitoid clasts have been found in almost all Buchans Group formations, although nowhere in significant numbers or volume as compared to the ore horizon (J.G. Thurlow, personal communication, 1982).

The nature of the granitoid clasts varies appreciably in hand specimen. A tentative field classification based on colour, grain size, presence or absence of quartz phenocrysts and mafic mineral content indicate twelve clast types (Table 44.1).

The average granitoid clast size as determined within several exposures of granitoid-bearing (arenaceous) breccia-conglomerate (see Table 44.2) on 20 level, MacLean Extension orebody, is 6.4 by 4.1 cm. The long dimensions of granitoid clasts range from 1 cm to more than 50 cm. Where intimately associated with the transported massive sulphide ore (e.g. 20-5 sublevel, 20-13 drift), average clast size is of the order of 16.5 by 10 cm and granitoid clasts comprise approximately 4 per cent by volume. In more arenaceous units, granitoid clasts average 4.2 by 2.0 cm and constitute 1 per cent of the rock. Rare granitoid clasts have been observed in tuffaceous rocks, both overlying and underlying the ore horizon. These clasts average 7.5 by 6.0 cm and comprise much less than 1 per cent.

Granitoid clasts are subrounded to well rounded and typically subspherical, although many are oval and elongate. They are consistently better rounded than other clast types in the breccia-conglomerate units.

Surface Observations

The Feeder Granodiorite is an irregularly shaped body of approximately 1.5 km^2 occurring in upper Wiley's River area (Fig. 44.1). Along its southern and western exposures the granodiorite can be seen in contact with rocks presumed to be part of the Topsails complex (Taylor et al., 1980). At the Feeder Granodiorite-Topsails contacts, Topsails granite shows a weakly developed chilled margin against the Feeder Granodiorite. Brick-red, fine grained, equigranular dykes, macroscopically similar to the Topsails granite cut Feeder Granodiorite. The granodiorite and the Topsails granite are both cut by diabasic dykes. No exposures of the contact between Feeder Granodiorite and Buchans Group rocks were found. No definite evidence of cross-cutting relationships between diabasic and granitic dykes was observed.

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[1] Contribution to Canada-Newfoundland co-operative mineral program 1982-1984. Project carried by Geological Survey of Canada.

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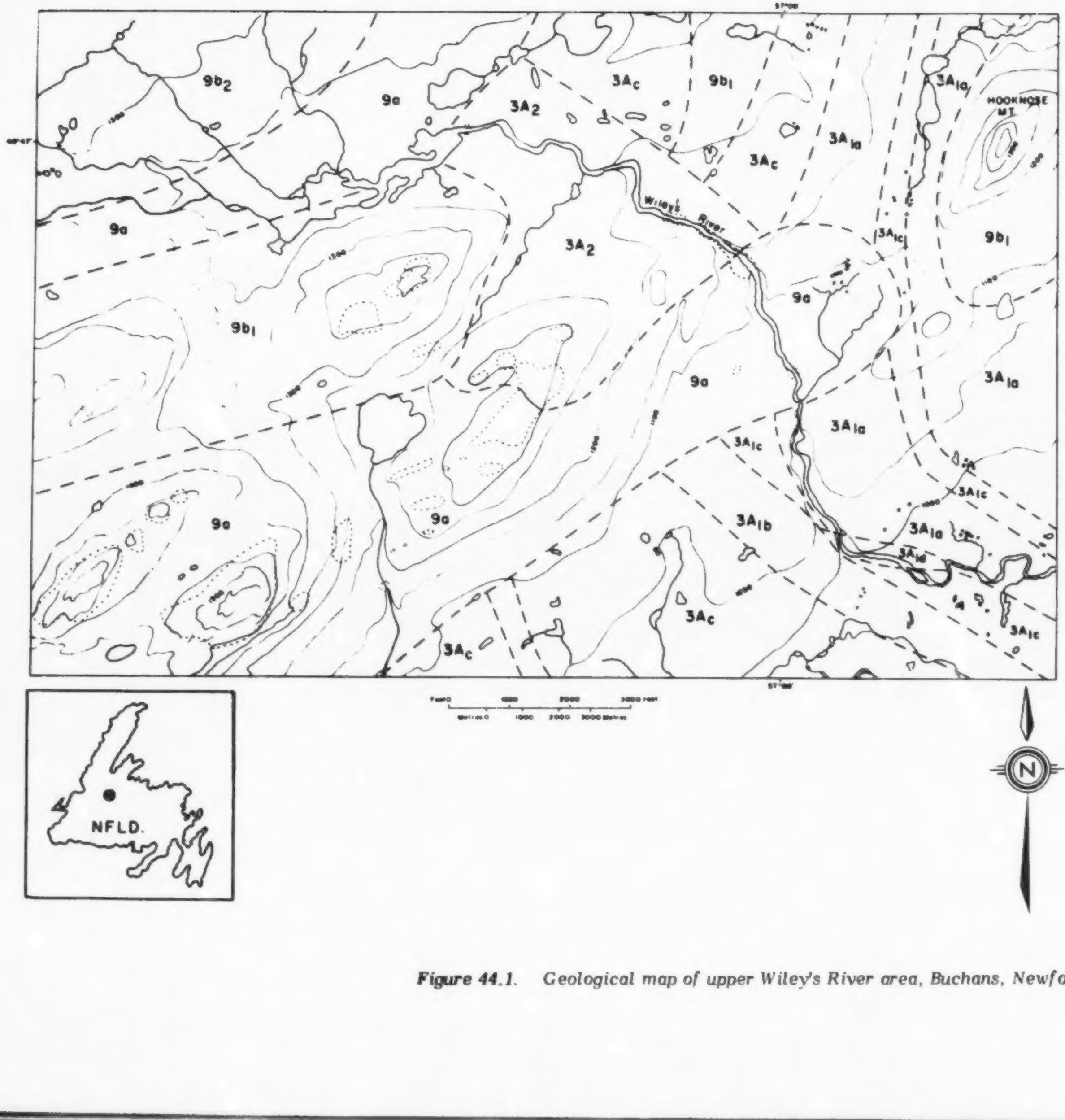

LEGEND

SILURIAN AND DEVONIAN

TOPSAILS GRANITE

9a	Alkali Feldspar granite: fine to medium grained, brick red granite
9b1 | 9b2	Mafic Intrusives (associated with Topsails Granite): fine to coarse grained diabase ($9b_1$) and gabbro ($9b_2$).

ORDOVICIAN-SILURIAN

BUCHANS GROUP

$3A_a$ | $3A_c$	Footwall Arkose: $3A_a$, lithic arkose; $3A_c$, basaltic lava pillow lava, pillow breccia.
$3A_{1a}$ | $3A_{1b}$ $3A_{1c}$ | $3A_{1d}$	Wiley's Prominent Quartz Sequence: Stratigraphic volcanic equivalent of 3A; characterized by quartz crystals commonly exceeding 1 cm in diameter; $3A_{1a}$, rhyolite flows and tuffs; $3A_{1b}$, dacitic pyroclastics; $3A_{1c}$, basaltic lavas, pillow lavas; $3A_{1d}$, tuffaceous siltstone.
$3A_2$	Feeder Granodiorite: whitish-brown, medium grained biotite granodiorite, with coarse grained quartz phenocrysts.

SYMBOLS

Geological boundary (defined, assumed)

Outcrop boundary (examined)

Elevations in feet above mean sea level

Approximate magnetic declination: 28° W

Formation numbers taken from and geology modified from "Geological Map of Buchans Area, Newfoundland," by Thurlow and Swanson, 1982.

Figure 44.1. *Geological map of upper Wiley's River area, Buchans, Newfoundland.*

The Feeder Granodiorite is a whitish brown rock, which becomes increasingly reddish toward the contact with the Topsails granite in Wiley's River area. The granodiorite is medium grained with abundant coarse grained quartz phenocrysts. Quartz crystals are generally rounded (5-10 mm average diameter), clear, locally appear as aggregates of crystals rather than true individual phenocrysts, and comprise 25-30 per cent of the rock by volume. The predominant feldspar is plagioclase, comprising 55-65 per cent of the rock, that is subhedral (locally euhedral), white and frequently darkened red-brown (by hematite). Fine grained clots of subhedral biotite crystals constitute 5 per cent. A fine grained pink-brown mineral (potash feldspar?) occurs interstitially to the quartz phenocrysts and the plagioclase (plus biotite) masses, and comprises 5 per cent of the rock.

The Topsails granite in this area is brick-red, ranges from fine- to medium-grained and is consistently equigranular. All feldspars are medium to dark red and comprise 65 per cent of the rock. Quartz crystals are clear, 1-3 mm across and form 30 per cent of the rock and biotite 5 per cent. The granite is miarolitic, especially near the contact with Feeder Granodiorite. The cavities are typically 1 mm in diameter, although near the contact they are 3-5 mm and partly filled with variable amounts of quartz,

Table 44.1

Field Classification of Granitoid Clasts

Clast type	Dominant colour, groundmass	Grain size	Phenocryst type	Mafic mineral content	Distinguishing features
1	strong-moderate brown-red	f.-m.g.	qtz. (c.g.)	variable; f.-m.g., generally distinct	colour strong brown-red; f.-m. grain size; presence of qtz. phenocrysts
2	strong-moderate brown-red	f.g.	equigranular	f.-m.g., distinct, variable	colour, strong-mod. brown-red; f. grain size; absence of qtz. phenocrysts
3	black & white with light browns, occasionally greenish or greyish	m.-c.g.	rare qtz. (c.g.)	m.-c.g.; distinct and indistinct in different clasts	coarse grain size; equigranular; spotted colour (black and white)
4	moderate-light brown (weak red)	m.g., rarely f.g.	qtz. (c.g.); rock may be m.g. & equigranular	variable; distinct & indistinct	qtz. phenocrysts; lighter red colour than type 1, otherwise the same, includes medium grained equigranular equivalents
5	light brown-pink darkened with mafic minerals in some	f.-m.g.	equigranular	generally distinct except when very abundant & f.g.	absence of qtz. phenocrysts; same colour as type 4, or even less pink (or red)
6	variable, light green with white & light brown	f.-m.g.	qtz. (m.-c.g.) rare m.g. plag.	generally indistinct variable	presence of qtz. phenocrysts; large amount of qtz. present; absence of brown & especially red colours except in isolated crystals
7	grey-white, rarely very light brown	f.g. (rarely m.g.)	equigranular	typically indistinct, content varies from 0-20%	white and/or grey colour; commonly with pyrite
8	greenish-yellow with occasional red tinges	f.-m.g.	qtz. (m.g.)	indistinct	vague crystal boundaries, with the exception of qtz. phenocrysts; most likely a volcanic rock
9	dark-moderate greenish with specks of white (plag.), red (K-feldspar) and qtz.	f.g.	equigranular; rare m.g.	abundant, distinct, probably amphibole	dark, spotted appearance; fine grained; seen only in siltstone breccia
10	dark green with grey & light brown	f.g.	K-feldspar & plag. (m.g.) rare qtz. (smaller)	abundant (to 40%) distinct	similar to type 9 but with abundant plag. phenocrysts – only one sample seen
11	strong brown-red with white	f.-m.g.	qtz. (m.g.)	few to 5%, distinct	very abundant qtz; brown-red colour
12	variable; a mixture of whites, greens and weak browns	m.-c.g.	equigranular	unaltered, 10-15%	large grain size; equigranular; greenish plag. crystals (?)

Table 44.2

Classification – MacLean Extension Orebody
(modified after E.A. Swanson, personal communication, 1982)

Ore Horizon Sequence in MacLean Extension area	Upper Baritic Ore-Bearing member (without granitoid clasts)	Baritic unit
		Tuffaceous or breccia unit
		Baritic unit
	Felsic Pyroclastic member	Strongly lithic beds with isolated sulphide clasts; occasional polylithic breccia bed with minor granitoid clasts
	Lower Ore-Bearing member (Generally gradational from high grade at bottom to low grade arenaceous granitoid-bearing breccia-conglomerate. The top baritic bed seems distinct).	Baritic low grade polylithic ore breccia
		Granitoid-bearing breccia-conglomerate with arenaceous matrix. Beds of arenaceous wacke within unit
		Granitoid-bearing ore breccia-conglomerate; low grade with some arenaceous matrix
		Polylithic ore breccia; matrix becomes increasingly arenaceous towards top
		Mainly massive sulphide, in part streaky with minor lithic material
Intermediate Footwall Formation		Interbedded and altered mafic to felsic flows, pyroclastic rocks and volcanic breccias, related tuffaceous pyritic siltstone and wacke

specular hematite, fluorite and a silvery grey unidentified mica. At the contact, the granite shows a weakly developed graphic texture.

Summary

Granitoid clasts within the Buchans Group breccia-conglomerate beds and pyroclastic units comprise several lithologic types. Those clasts with coarse grained quartz phenocrysts (to 1 cm) in a brown-red groundmass are megascopically similar to the Feeder Granodiorite in the Wiley's River area.

The relationship of the Feeder Granodiorite to the Buchans Group remains unknown. Topsails granite has a chilled margin against the Feeder Granodiorite. Brick-red granitic dykes of presumed Topsails affiliation cut the Feeder Granodiorite. Both intrusive bodies are cut by diabasic dykes.

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THE MACLEAN EXTENSION OREBODY, BUCHANS, NEWFOUNDLAND[1]

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Binney, W.P., Thurlow, J.G., and Swanson, E.A., The MacLean Extension orebody. Buchans, Newfoundland; in Current Research, Newfoundland Department of Mines and Energy, Mineral Development Division, Report 83-1, p. 219-225, 1983.

Also in Current Research, Part A, Geological Survey of Canada, Paper 83-1A, p. 313-319, 1983.

Abstract

About 53 per cent of the ore mined to date at Buchans, Newfoundland has been from transported volcanogenic massive sulphide deposits. A detailed sedimentological investigation is in progress to determine the source, transport mechanism and deposit lithologies for the MacLean and MacLean Extension orebodies. This report describes briefly lithological and sedimentological features of the MacLean Extension orebody. Two ore units occur in a sequence of felsic pyroclastic rocks of the Lucky Strike Ore Horizon Sequence. Three lithological units: sulphide matrix ore, polylithic breccia-conglomerate and arenaceous conglomerate are distinguished in the lower ore unit. The upper ore unit is exposed at one location in the MacLean Extension workings. Here two sedimentary cycles have been identified. Sedimentological work to date supports the concept of ore emplacement by subaqueous sedimentary gravity flows with deposition in channels. Several individual flows have been recognized based on their distinctive lithologies.

Introduction

From 1928 to 1978, the volcanogenic massive sulphide deposits of the Buchans camp yielded 15 813 000 tonnes of ore with an average grade of 14.62% Zn, 7.60% Pb, 1.34% Cu, 114.77 g Ag/t and 1.34 g Au/t (Thurlow and Swanson, 1981). About 53 per cent of this total was transported ore[5] from the Lucky Strike North, Two Level, Rothermere, MacLean, Oriental #2 and Old Buchans Conglomerate ore deposits (Fig. 43.1). The economically most significant transported ore has been the Rothermere and MacLean orebodies. The MacLean Extension orebody, currently under development in

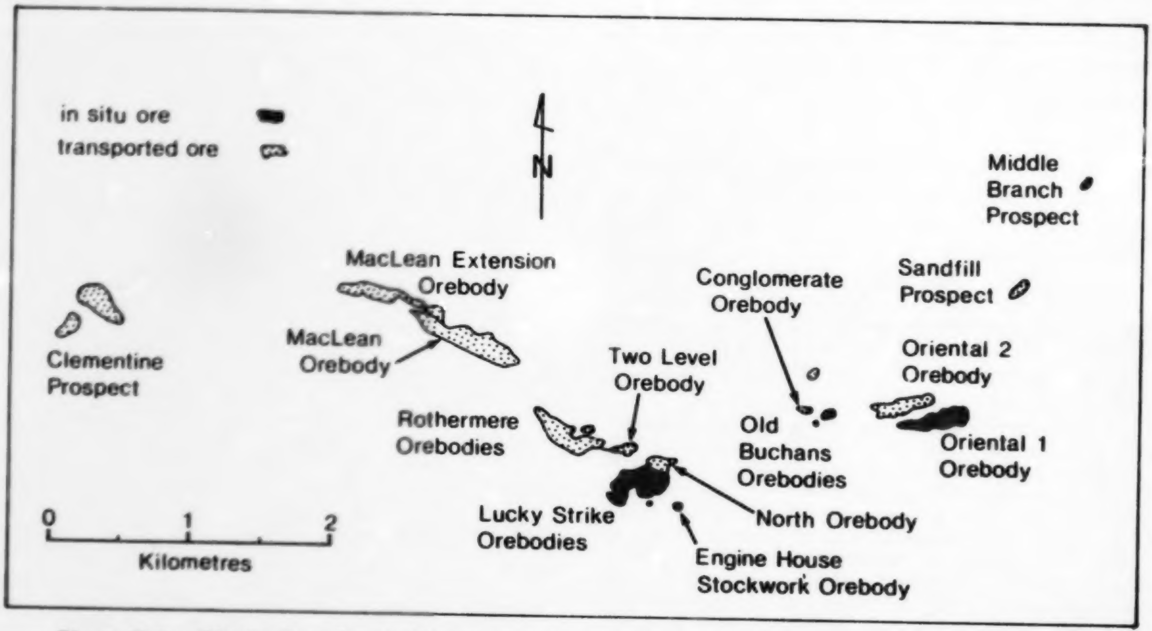

Figure 43.1. *Distribution of orebodies and ore types at Buchans, Newfoundland projected to surface. After Thurlow and Swanson (1981) with MacLean Extension orebody added.*

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[1] Contribution to Canada-Newfoundland co-operative mineral program 1982-84. Project carried by Geological Survey of Canada.

[2] P.O. Box 1152, Truro, Nova Scotia B2N 5H1

[3] Abitibi-Price Inc., Buchans, Newfoundland A0H 1G0

[4] ASARCO Incorporated, Buchans, Newfoundland A0H 1G0

[5] Transported orebodies are elongate-tabular accumulations composed of discrete high grade sulphide fragments and occurring in paleotopographic depressions at and near the same stratigraphic horizon as the major in situ orebodies (Thurlow and Swanson, 1981).

September 1982, is the most northwesterly deposit on the Rothermere-MacLean trend and contains 339 400 tonnes of ore with an average grade of 10.22% Zn, 5.90% Pb, 1.42% Cu, 88.02 g Ag/t and 0.72 g Au/t.

The present study, undertaken by Binney, is an extension of an ongoing study by Thurlow, Swanson and other company personnel. The study emphasizes the nature, origin and exploration guides for transported ore and will be concentrated on the MacLean and MacLean Extension orebodies. This report outlines some stratigraphic and sedimentological relationships of the MacLean Extension orebody.

Acknowledgments

W.P. Binney would like to thank the staff of ASARCO and Abitibi-Price for their generous assistance throughout this study.

R.V. Kirkham and W.H. Poole reviewed the manuscript and made many useful comments.

Geological Setting

The following descriptions of lithology, structure and sedimentological relationships apply only to the MacLean Extension orebody. These are based on observations in underground workings and diamond drill core. For general descriptions of the transported ores of the Buchans camp see Thurlow and Swanson (1981), Walker and Barbour (1981) and Calhoun and Hutchinson (1981).

The mineralization is contained within the Lucky Strike Ore Horizon Sequence, a group of predominantly felsic pyroclastic rocks with interbedded flows, breccias and volcaniclastic sedimentary rocks. The Lucky Strike Ore Horizon Sequence conformably overlies the Intermediate Footwall, a complex assemblage of altered volcanic and volcaniclastic rocks (Thurlow and Swanson, 1981).

Only those portions of the Lucky Strike Ore Horizon Sequence that contain transported sulphides and/or barite have been examined in detail. The lateral distribution of two ore-bearing units in the MacLean Extension orebody is shown in Figure 43.2 and as a schematic idealized cross-section in Figure 43.3. The MacLean Extension orebody adjoins the MacLean deposit but the contact relationships are obscured by faults and a diabase dyke.

The lower ore unit conformably overlies green dacitic tuffaceous rocks along an irregular contact. Mineralization occurs as clasts of sphalerite-galena, sphalerite-galena-chalcopyrite and barite in a matrix which consists of varying proportions of lithic detritus, galena, sphalerite and barite. Overlying the lower ore unit is a sequence of felsic pyroclastic rocks including volcanic breccias.

The upper ore unit, known in mine terminology as the "#4 baritic zone", conformably overlies these felsic pyroclastic rocks. The ore beds within the upper unit are notable for their high content of barite in addition to galena, sphalerite and small lithic fragments. Felsic pyroclastic rocks of the Lucky Strike Ore Horizon Sequence form the hangingwall of the MacLean Extension orebody.

Both major and minor faults occur in the MacLean Extension orebody. A major thrust fault defines the southern margin of the orebody. Thrust and normal faults with small displacements cut the ore beds at numerous locations. Offsets on these faults range from a few centimetres to tens of metres. Felsite and diabase dykes also cut the ore beds, but in most areas little offset of the ore exists across the dykes.

The Lower Ore Unit

The lower ore unit ranges in thickness from 0 to greater than 15 m. Within the unit a virtual continuum exists from high grade sphalerite and galena containing scattered lithic clasts, through sphalerite and galena blocks and lithic

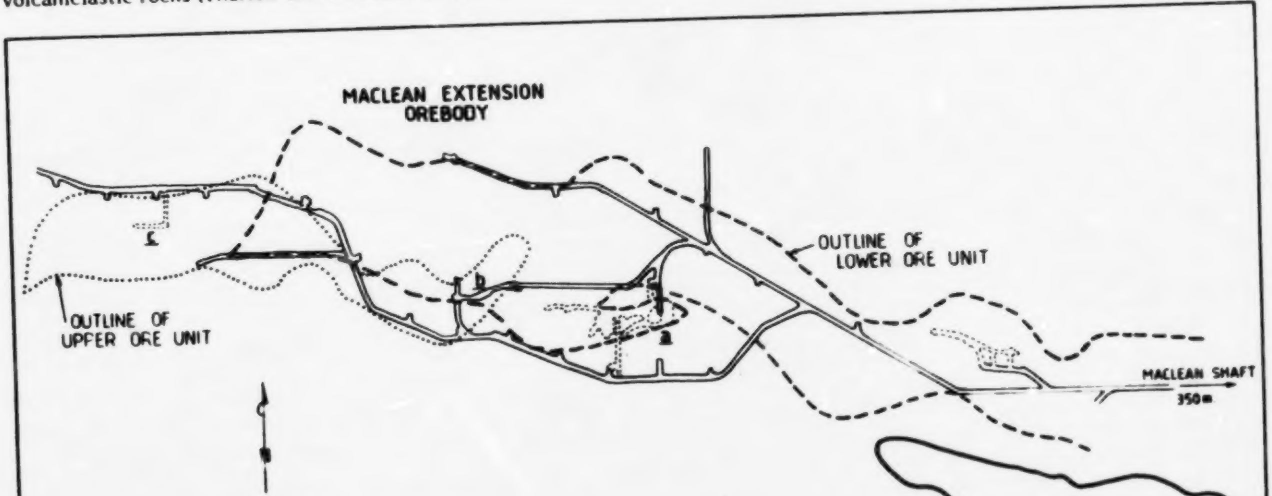
MACLEAN EXTENSION OREBODY
OUTLINE OF LOWER ORE UNIT
OUTLINE OF UPPER ORE UNIT
c
b
a
MACLEAN SHAFT
350m
50m
MACLEAN OREBODY

Figure 43.2. Vertical projection of the ore-bearing units of the MacLean Extension orebody to the 20 level, MacLean Shaft. Letters are locations referred to in text.

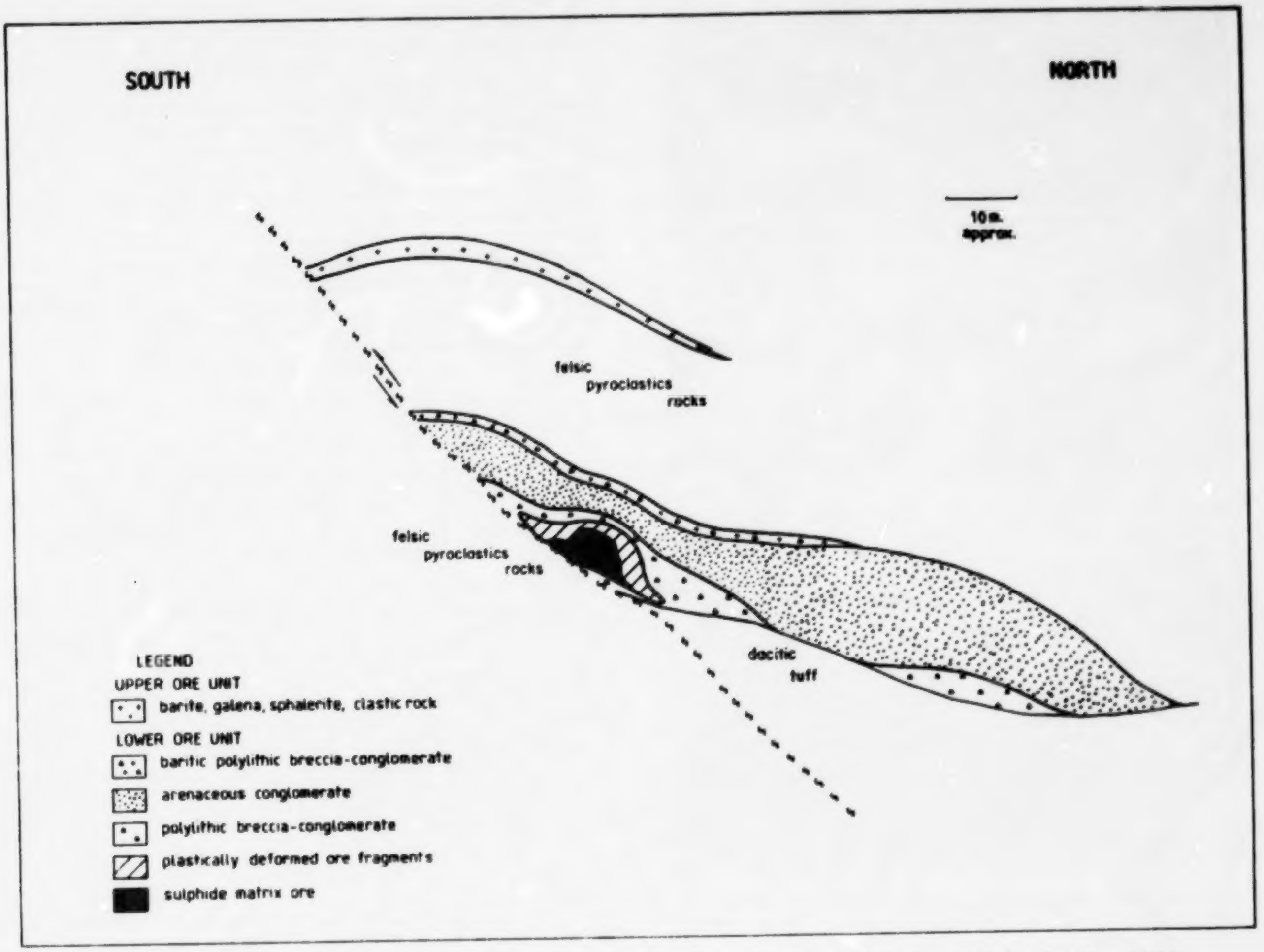

Figure 43.3. *Schematic north-south cross-section of the MacLean Extension orebody showing some generalized lithological units.*

fragments in a clastic matrix, to arenaceous conglomerate with minor pebble-size detritus including rare sphalerite and galena clasts.

Three lithological units have been defined that are believed to be fundamental divisions within this continuum. The divisions are based on the nature and distribution of the sulphide and lithic components of the rock without reference to the grade of the ore. Several intermediate lithologies are of local significance and by adding modifiers to the basic units most beds in the lower ore unit can be described accurately. The three main lithological units will be referred to as sulphide matrix ore, polylithic breccia-conglomerate and arenaceous conglomerate.

Sulphide matrix ore consists of a fine grained matrix of sphalerite, galena and locally barite with a minor amount of admixed lithic detritus. Within the matrix are subangular to subrounded clasts including siltstone, rhyolite, altered Intermediate Footwall, pyritic stockwork and barite (Fig. 43.4). All these clast types occur in the Intermediate Footwall or at the base of the Lucky Strike Ore Horizon Sequence in the vicinity of the Lucky Strike ore deposit or along the Rothermere-MacLean trend, the current suggested source and transport channel for the ore (Walker and Barbour, 1981). The clasts rarely exceed 15 cm in length and comprise less than 15 per cent of the unit. To date no sorting has been indicated by measurement of clast size and type for all clasts more than 1 cm in length in areas 0.5 m wide by the accessible height of the bed (generally 1-3 m). Segregation of clasts into distinct beds within the sulphide matrix ore has been noted.

Sulphide matrix ore occurs in a discontinuous bed at, or near, the base of the lower ore unit. Ore grades in this bed range from 15 to 40 per cent combined zinc and lead. In a sublevel of 20 level (a on Fig. 43.2) thin, laterally continuous layers of chalcopyrite in the matrix define planar zones in the rock. The bed of sulphide matrix ore changes thickness rapidly. Presently available exposures and drill core information suggest that the sulphide matrix ore grades into polylithic breccia-conglomerate with a change in the mode of occurrence of sphalerite and galena from the matrix to distinct clasts of ore.

Polylithic breccia-conglomerate comprises the broad central part of the lithological continuum between sulphide matrix ore and arenaceous conglomerate. It is distinguished from the sulphide matrix ore by its arenaceous matrix and from the arenaceous conglomerate by the number, size and variety of clasts. Breccia-conglomerate is the term chosen to describe this unit due to the angularity of a majority of

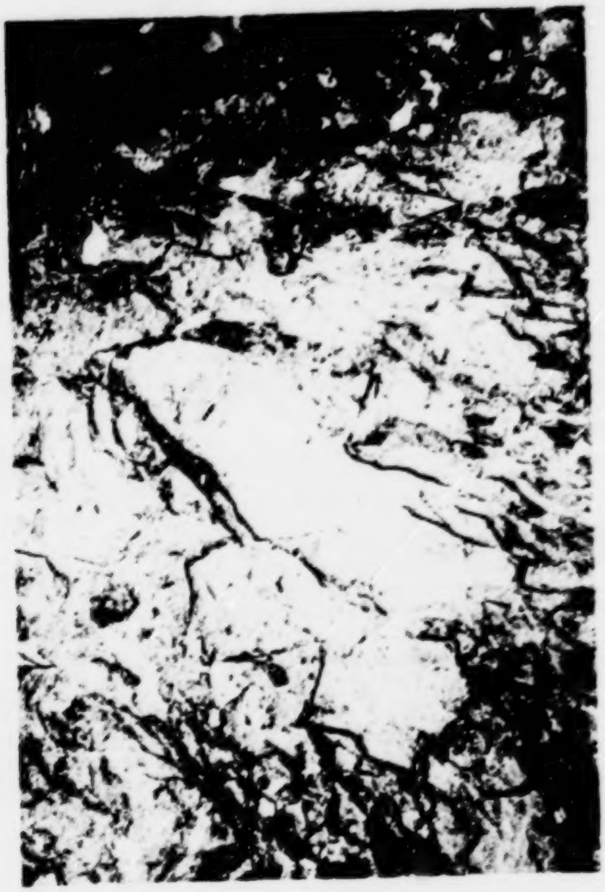

Figure 43.4. High grade sulphide matrix ore with some lithic clasts at location a, Figure 2. Rock bolt is 12.6 cm across.

the clasts. However, polylithic breccia-conglomerate contains subangular to subrounded clasts which include siltstone, rhyolite, altered Intermediate Footwall, stockwork pyrite, mafic volcanic rocks, felsic tuff, jasper, sphalerite-galena-chacopyrite and barite. In addition, sphalerite-galena fragments are common and granitic boulders are present in local concentrations. The granitic boulders, although larger than most other clasts, are subrounded to rounded. They are also the only clast type not recognized in situ in the Intermediate Footwall or the Lucky Strike Ore Horizon Sequence. For further information on granitic clasts the reader should refer to Stewart (1983). The size range of the clasts in the breccia-conglomerate is considerable with large boulders (up to 4.5 by 2.4 by 1.8 m, minimum measurements) in a sand-size matrix. In typical polylithic breccia-conglomerate the clasts range from 1 to 30 cm long and comprise from 15 to 50 per cent of the rock.

Polylithic breccia-conglomerate occurs overlying, underlying and adjacent to sulphide matrix ore, as isolated beds at the base of the lower ore unit, within the arenaceous conglomerate and at the top of the lower ore unit (Fig. 43.3). In the latter case, barite fragments are concentrated in a polylithic breccia-conglomerate. In marginal parts of the lower ore unit this baritic polylithic breccia-conglomerate rests directly on the footwall dacitic tuff and is overlain by felsic pyroclastic rocks.

The relationship between the sulphide matrix ore and polylithic breccia-conglomerate has been documented in several areas of the MacLean Extension workings. Along a drift at location b (Fig. 43.2) sphalerite-galena-barite sulphide matrix ore with less than 5 per cent lithic fragments overlies dacitic tuff or a thin polylithic breccia-conglomerate bed. Above and adjacent to the sulphide matrix ore are large blocks of sphalerite-galena, and sphalerite-galena-chalcopyrite in a clastic matrix (Fig.43. 5). The ore clasts are typically tabular with length-to-width ratios from 3 to 10. They exhibit draping and plastic deformation over and against adjacent lithic detritus (pebbles, cobbles and boulders). Ore clasts are less abundant and matrix more abundant farther away from the sulphide matrix ore, and some granitic clasts are present. The granitic clasts tend to be large (20 to 50 cm in diameter) and are concentrated in a

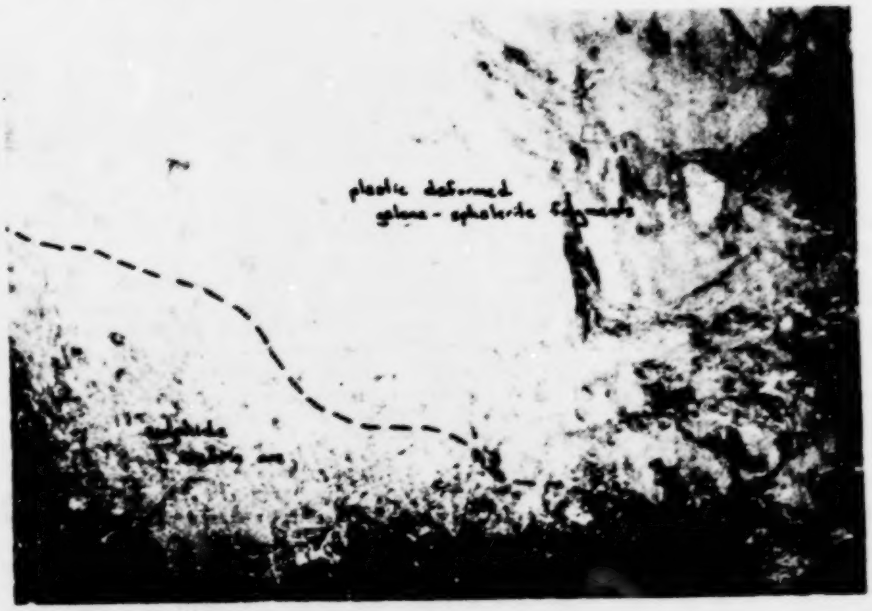

Figure 43.5

Contact of sulphide matrix ore and plastically deformed galena-sphalerite fragments in a matrix of lithic detritus at location b, Figure 2.

distinct stratigraphic unit. This unit is succeeded by a typical polylithic breccia-conglomerate with a wide range of clast lithologies and sizes. The complete sequence is observed in a strike length of 15 m.

A separate lithological unit, arenaceous conglomerate, occurs also in the lower ore unit of the MacLean Extension orebody. This unit has a wide lateral distribution judging from drill intersections but has been found only in one location in the underground workings. The rock consists of an arenaceous matrix with less than 10 per cent subangular to subrounded clasts. Rhyolite and granite comprise two thirds of all the clasts. Other types include siltstone, altered Intermediate Footwall, mafic volcanic rocks, sphalerite-galena and sphalerite-galena-chalcopyrite. Where examined underground, the arenaceous conglomerate overlies footwall dacitic tuffaceous rocks and is overlain by polylithic breccia-conglomerate, but in drill core this unit can be seen to overlie polylithic breccia-conglomerate as well.

The Upper Ore Unit

The upper ore unit is separated from the lower ore unit in the MacLean Extension orebody by 30 to 50 m of felsic pyroclastic rocks (Fig. 43.3). An excellent exposure, undisturbed by faults, exists in a drift above 20 level (location c in Fig. 43.2). Details of the geology of the south wall of this drift are shown in Figure 43.6. Notable features of the exposure are cyclic units of barite-rich transported ore and graded beds of sandy sedimentary rocks at the top of the ore layers.

At the base of the exposure, massive, yellow-green felsic tuff is conformably, but irregularly, overlain by a bed containing single barite crystal clasts (up to 5 cm long) in a matrix of barite, galena, sphalerite and minor lithic detritus. Other clast types include siltstone, rhyolite, altered Intermediate Footwall and basalt. Granitic clasts are absent. This massive bed grades upward into about 10 cm of sandy lithic detritus and barite. Above the sandy bed, and gradational with it, is a thin bed of felsic tuffaceous rock. The combined thickness of the sandy and tuffaceous beds ranges from 5 to 50 cm at location c.

A second cycle consisting of a barite-galena-sphalerite-rich basal portion overlain by arenaceous, polylithic pebble conglomerate grading upward into sandy and tuffaceous rocks rests on the basal graded unit.

The baritic beds contain cobbles and boulders of galena-sphalerite exceeding 30 cm in length as well as other large blocks of siltstone, rhyolite and basalt. These occur in localized areas associated with the barite-rich ore beds and in places have penetrated the fine grained top of the first cycle (Fig. 43.7).

Origin of the Ore Sequence

Earlier work on the genesis of the transported ores by Walker and Barbour (1981) and Calhoun and Hutchinson (1981) was restricted to diamond drill core and a limited number of ore exposures remaining in the MacLean orebody. The MacLean Extension orebody is presently being developed for mining and consequently contains some excellent exposures.

This is an ongoing study but preliminary results indicate several features bearing on the transport and deposition of the ore beds. Thurlow (1977) suggested that the transported ores of the Buchans camp represent deposits from subaqueous sedimentary gravity flows initiated by explosive volcanic eruption or local earthquake. The size and angularity of the clasts, in addition to the types and diversity of lithologies represented by the clasts, all support this hypothesis.

Sedimentary gravity flows can be divided into four main types based on the sediment support mechanisms. These types are turbidity currents, fluidized sediment flow, grain flow and debris flow (Middleton and Hampton, 1976). Each type of flow has specific depositional features.

Within the MacLean Extension orebody, and especially the lower ore unit, a range of depositional features have been observed that suggest complex channel filling from several

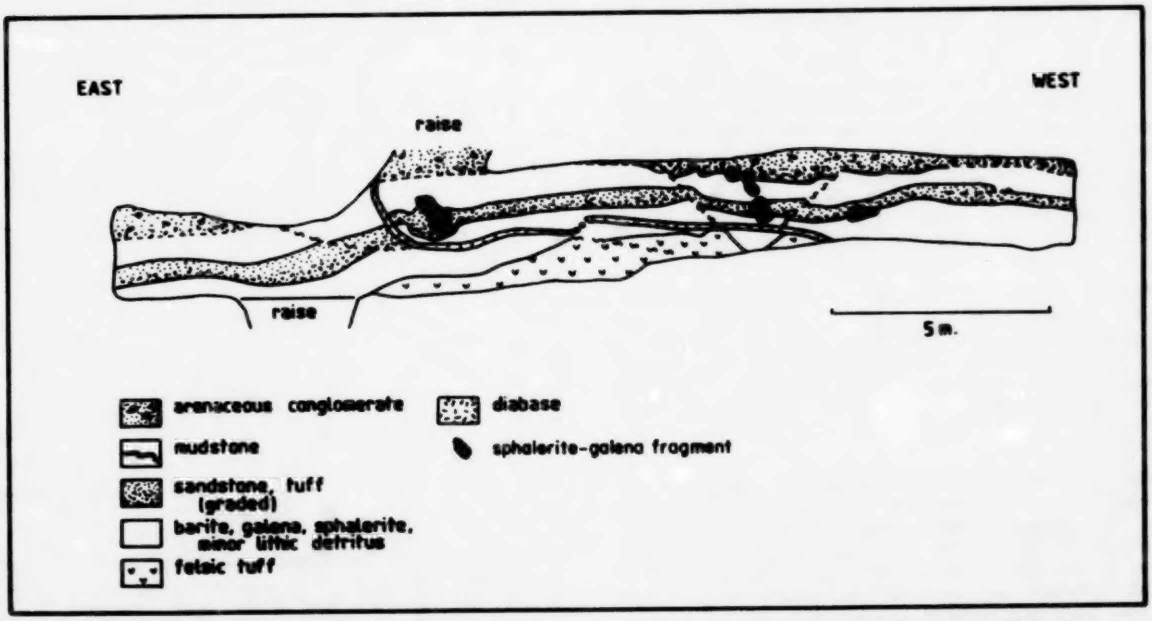

Figure 43.6. Subdivisions of the upper ore unit along the south wall of drift, above 20 level, location c, Figure 2.

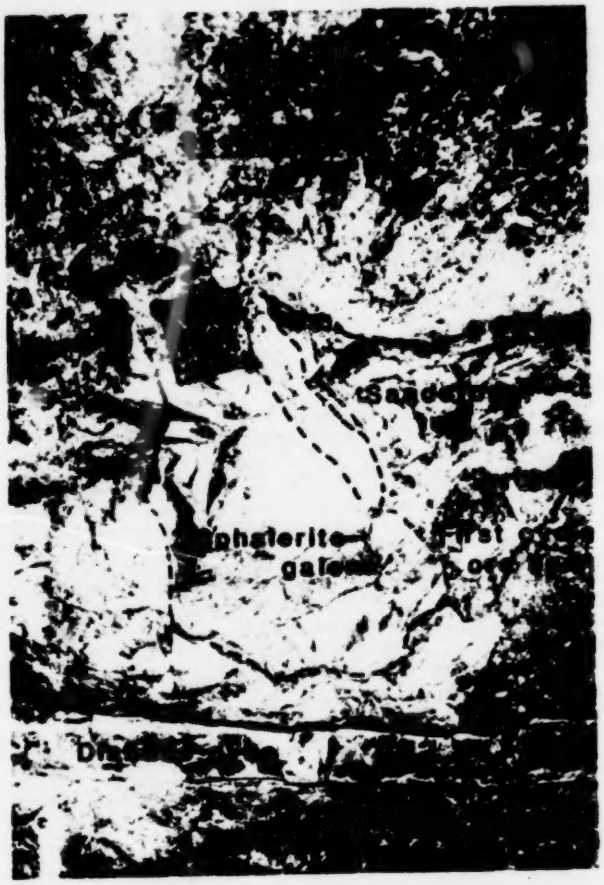

Figure 43.7. Galena-sphalerite block penetrating the top of the first cycle ore bed of the upper ore unit at location c, Figure 2. Rock bolt is 12.6 cm across.

episodes and types of sedimentary gravity flows. Individual flows can be separated by their distinct clast lithologies. The most obvious example is the baritic polylithic breccia-conglomerate which is at the top of the lower ore unit in many areas. Underlying the baritic polylithic breccia-conglomerate is a polylithic breccia-conglomerate bed with a distinctive high content of granitic fragments. Both beds are localized, probably in topographic depressions which existed at the time of emplacement.

With the exception of the above beds, most of the lower ore unit is a sequence of beds grading from sulphide matrix ore to coarse sphalerite-galena blocks in a lithic matrix, to sphalerite-galena-bearing polylithic breccia-conglomerate, and to arenaceous conglomerate with few lithic clasts and only rare sphalerite-galena clasts. There is an overall sorting of dense, sulphide-rich material toward the base of the lower ore unit.

The contacts between massive sulphide matrix ore and polylithic breccia-conglomerate beds are quite steep suggesting a subaqueous debris flow with matrix strength as the transport mechanism for some high density, sphalerite-galena-rich material (Middleton and Hampton, 1976). Turbidity currents can account for graded units within arenaceous conglomerate beds.

Several beds were selected for clast counts in the MacLean Extension workings. Modifications were made to Walker's (1975) method to typify grading. Rather than vertical traverse lines, an area was chosen 0.5 m wide through the entire thickness of the bed. Within this area the length and width of all clasts over 1 cm long were recorded, as well as clast type and height in the bed. The length of galena, sphalerite, chalcopyrite and barite clasts was corrected to allow for their greater density. This was done by multiplying clast length by clast density divided by a density of 2.8 gm per cm^3. A plot of clast height in the bed versus length is presented in Figure 43.8 for a polylithic breccia-conglomerate bed that contains granitic clasts. Inverse grading in the lower part of the bed is succeeded by a disorganized to normally graded top. This sequence, duplicated by clast measurements in the bed at a second location, suggests proximal deposition from a high-sediment-concentration turbidity current (Walker, 1975).

The supply of lithic and sulphide detritus to the basin, although intermittent, was not interrupted by long periods of quiescence. This is suggested by the massive nature of the lower ore unit and the recognition of several separate flow deposits. The sedimentary gravity flows would have the capacity to erode any thin intervening pyroclastic units.

The upper ore unit reflects a change in the depositional history. Two discrete cycles of ore deposition are separated by a thin bed of sandy and tuffaceous rocks. The transport mechanism, although similar to that of the lower ore unit, appears to have a greater component of turbulent flow.

Summary and Exploration Guides

The MacLean Extension orebody contains two main ore units, both comprising distinct and interrelated lithologies. The lower ore unit is characterized by pebble and boulder size ore and lithic clasts in a matrix which is predominantly sandy lithic material with the exception of the economically important sulphide matrix ore. In this ore the matrix is galena and sphalerite with or without barite. The upper ore unit is of different character with at least two distinct cycles of deposition. At the base of each cycle is a bed of galena, sphalerite, barite and fine grained lithic detritus.

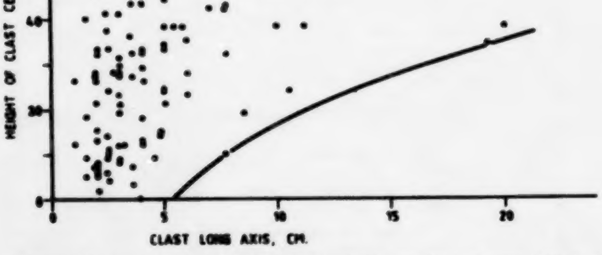

Figure 43.8. Plot of height of clast centre above base of bed versus corrected clast long axis (cm) for a polylithic breccia-conglomerate bed in the lower ore unit, MacLean Extension workings. The lower 35 cm of the bed is inversely graded. Curve is limit of largest clast.

Preliminary sedimentological work indicates that the ore-bearing beds are products of subaqueous sedimentary gravity flows. A few clast orientations determined in the MacLean orebody support previous interpretations that the ores were transported down the Rothermere-MacLean channel and could have been derived from the vicinity of the Lucky Strike in situ deposits. Thin, low grade arenaceous conglomerate units, widespread in diamond drill holes, can be traced laterally into thicker and denser gravity flow deposits containing high grade sulphide ores.

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A PRELIMINARY REPORT ON DRIFT PROSPECTING STUDIES IN LABRADOR [1]

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Klassen, R.A., A preliminary report on drift prospecting studies in Labrador; in Current Research, Newfoundland Department of Mines and Energy, Mineral Development Division, Report 83-1, p. 226-228, 1983.

Also in Current Research, Part A, Geological Survey of Canada, Paper 83-1A, p. 353-355, 1983.

Abstract

A study of glacial history and till geochemistry was begun in east-central Labrador during 1982. Field observations, chiefly of striae trends, indicate that regional directions of ice movement were eastward to southeastward in the southern part of the area, and northeastward in the northern part. Erratics of sedimentary rock derived from bedrock located west of the study area can be a significant component of glacial sediments.

Introduction

During 1982, the Geological Survey of Canada began a study of Quaternary geology in east-central Labrador that is designed to identify directions of ice movement, regional variation in till composition, and geochemical properties of till. This work is intended to provide a basis for future mineral exploration using glacial deposits in Labrador. This report is a preliminary account of field operations and observations; no laboratory results are presently available. Observations of ice flow direction and lithology of erratic clasts presented here provide a basis for determining the provenance of glacial dispersal trains, and for understanding variations in till composition.

Acknowledgments

The excellent field assistance of Mr. C. Lyall and Mr. A. Michelin is gratefully acknowledged. Mr. A.J. Willy, Brinco geologist, provided much geological information and contributed significantly to the success of field operations. Field logistics for the project, including aircraft support, were generously provided by Brinco Mining Ltd.

Location and Geology

The area studied is located in east-central Labrador and includes the west half of Rigolet (13J) and east half of Snegamook Lake (13K) map areas (Fig. 49.1). It occupies parts of the Nain and Grenville structural geological provinces and is underlain by Aphebian acidic intrusive and metamorphic rocks, Helikian and Aphebian sedimentary and volcanic rocks of Aillik and Croteau groups, Aphebian and older metamorphic rocks of quartzo-feldspathic lithologies, and Helikian and Aphebian metamorphic equivalents of Labrador Trough rocks and Seal and Croteau groups (Greene, 1974, Fig. 5). Uranium occurrences are known at various locations within the area, and include the Michelin deposit (Gandhi, 1978).

Previous Work

Few published Quaternary studies have been directly concerned with the area of Labrador described here. Surficial materials have been mapped at 1:250 000 scale by Fulton et al. (1980a, b). A brief report on ice flow directions in the central part of the study area has been given by Vanderveer (1982).

Methods

During August 1982, a field program of Quaternary geological mapping and till sampling was carried out in the study area using helicopter support. Base camp was located at 'Melody Lake', about 70 km southwest of the community of Makkovik (Fig. 49.1). During reconnaissance mapping flights, till samples were collected systematically at a density of about one per 10-20 km^2. Coverage of the entire area, however, was not uniform. Near known trains of mineralized boulders and sites of bedrock mineralization, sample density was increased to about one per 1-2 km^2. At this higher density it was more difficult to locate suitable landing sites and further decrease in spacing between samples was not practical. Near one boulder train, samples were collected at spacings of 75-250 m on foot traverses oriented perpendicular to directions of regional ice flow.

Pits were dug in till to depths of 40-100 cm, and samples were collected from the least oxidized soil horizon near the pit base. In all cases an attempt was made to sample below the zone of obvious iron staining, although commonly either bedrock or large clasts restricted sampling to the oxidized zone. Where soils were well developed, or where sample sites were located near known mineralization, multiple samples were collected from each pit and identified with regard to depth of burial and position within the weathering sequence. In all, 225 samples were collected.

Where possible, measurements of striation orientations and examination of lithologies of erratic clasts were made at the collection sites. In general, observations of this kind were best made in exposed locations where vegetation did not obscure outcrops and boulders.

Results and Discussion

Direction of Movement

Within the study area glacial striae vary in orientation from about southeast to northeast (Fig. 49.1) and are similar to patterns of ice flow outlined by Prest et al. (1968). Based on the streamlined shape of outcrops, ice flow had an eastward component and no evidence of westward movement was observed. Most measurements were made on hilltops, and the striae are thought to be the product of regional ice movement. They are, for the most part, aligned with the long axes of topographic ridges, suggesting a relation between landform and ice flow direction. At some locations,

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[1] Contribution to Canada-Newfoundland co-operative mineral program 1982-84. Project carried by Geological Survey of Canada.

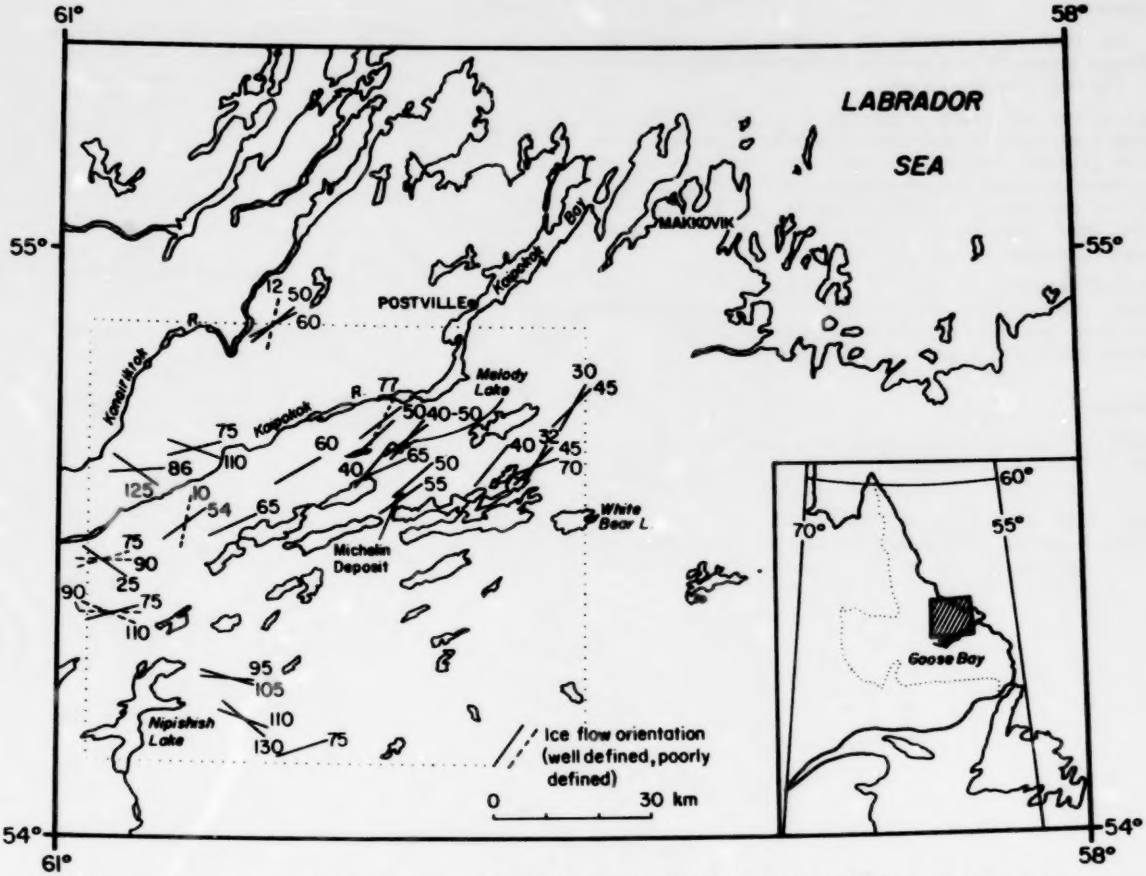

Figure 49.1. Ice flow trends within the study area (outlined), based chiefly on glacial striae. Regional movement is thought to be generally eastward, based on streamlined bedrock landforms. Numbers indicate orientation in degrees east of north; magnetic declination N32°W assumed throughout the study area.

however, for example in the area of Melody Lake, striae were oriented obliquely to the trend of valleys and ridges, and obliquely to directions of ice flow indicated by ribbed moraine deposits which trend across valley floors. There, the ribbed moraine may have been formed later than the striae on neighbouring hilltops, during a phase of ice flow that was controlled topographically.

Several striae orientations were commonly observed at each site, with one set being more common and better developed than all others. If the best developed sets are contemporaneous and formed during the same phase of flow, the data indicate collectively that ice entered the area from the west and northwest, and moved easterly to southeasterly across the southern part of the area, and northeasterly across the northern part. Ice in the northern part moved towards the valley of Kaipokok River and Kaipokok Bay, and these low-lying areas were likely main pathways of ice movement to the outer coast.

Other striae, which are presumed to be older because they are fewer in number and do not occur in the glacial polish of outcrops, indicate a west-east trend of ice movement. At two sites poorly developed striae of possible glacial origin trended nearly north-south, although directions of ice movement during that phase of ice flow are not known; this trend was also shown by a single measurement made by Vanderveer (1982, Fig. 2).

Lithologies of Erratics

At many sites, erratics of distinctive appearance were found, some of which are not known to have bedrock sources within the study area. The types of erratics identified most easily include red and pink quartzite, red arkose, mudstone, and polymictic conglomerate; of these, the quartzites were found throughout the study area, the others were seen chiefly in the northwestern part. The erratics of red quartzite are most likely derived from Helikian sedimentary formations lying west of the study area, possibly the Red Quartzite Formation of the Seal Group. They are up to ten per cent by weight of the 4-6 mm size fraction of till samples, and they demonstrate that till of the study area can have a significant component of far-travelled (>50 km) debris. The other sedimentary erratics, mentioned above, are most likely derived from sedimentary rocks of the Croteau Group that outcrops near the headwaters of Kaipokok River.

Conclusions

This study is currently at a preliminary stage and conclusions presented here are based chiefly on field observations. The main conclusions are:

1. During the last regional glaciation ice moved into the study area from the west and northwest. Flow directions were generally towards the east and southeast in the southern part, and towards the northeast in the northern part of the study area. In some areas later ice flow may have been channelled topographically within valleys, based on orientations of ribbed moraine.
2. Erratics derived from bedrock sources located west of the study area include sedimentary rocks such as red quartzite, and this far-travelled (>50 km) debris can constitute significant proportions of till.

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